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PROFESSORS' SALARIES[1]

ARE EQUITABLE SALARIES PAID TO PROFESSORS?

By Dr. WILLIAM A. NOYES

PROFESSOR OF CHEMISTRY, UNIVERSITY OF ILLINOIS

THE professors in our colleges and universities are not receiving their fair share of the returns coming to others from the rapidly increasing prosperity of the country. No one will claim that professors were overpaid in 1900. In order that they may retain their economic status in comparison with other men and women their salaries must be increased in the same proportion as the income of the average citizen. Salaries have fallen far below this equitable level.

The volume of "Statistical Abstracts" of the United States published by the government in 1928 gives the following numbers in millions of dollars for the values of farm products, mineral products and the values added to raw materials by manufacture in the years 1900 and 1925:

	1900 Millions of Dollars	1925 Millions of Dollars
Farm products	3,549	13,034
Mineral products	1,110	5,678
Manufacture	5,123	26,778
	9,782	45,490

To avoid an unfair use of the statistics for farm products, it should be stated that the farm population remained stationary during this period, while the total population increased 50 per cent., or from 77.1 millions to 115.4 millions.

[1] A symposium on the salary question arranged by the Committee of One Hundred on Scientific Research, American Association for the Advancement of Science, Shrine Lounge, Des Moines, Iowa, December 31, 1929.

Dividing the values of the products by the population, we have a per capita production of $128 in 1900 and of $394 in 1925. We may put this concretely by saying that where an individual received for his labor and capital, on the average, $100 in 1900, he received, on the average, $300 in 1925.

This gives, however, a very exaggerated idea of the increase in our powers of production. The average of the index numbers for wholesale prices for the years 1898–1902 was 77.7. The similar average for 1923–27 was 152. In other words, a gold dollar was worth just about one half as much in purchasing power in 1925 as it was worth in 1900. Making allowance for this change in the value of the dollar, the increase in the real value of our production was about 50 per cent. instead of 200 per cent.

Salaries and wages are paid, however, in the depreciated money indicated by the index numbers, and it would seem to be a fair conclusion that, if professors in our colleges and universities are to maintain the same economic status relative to other classes of citizens which they held in 1900, their salaries must be increased threefold. A professor of a given rank who received a salary of $2,000 in 1900 should have received $6,000 in 1925. There are doubtless some factors which make this conclusion not wholly accurate, but we may take it as approximately true until some one is able to furnish a statistical analysis which will prove its fallacy.

To determine how closely this equitable basis for salaries has been approached, the presidents of nine universities were asked to furnish a statement of the average salaries paid to executive officers who do no teaching and to professors, associate professors and assistant professors, in 1900 and in 1925. The presidents of Yale, Harvard, Ohio State, Michigan, Illinois, Wisconsin and California furnished the data requested. The other two universities were unable to do this. I wish here to express my appreciation of the courtesy shown in furnishing this information. The averages are given in the table.

AVERAGE SALARIES

	1900	1925	Increases
Executives	$3,115	$6,904	122 per cent.
Professors	2,791	5,318	87 per cent.
Assoc. professors	1,956	3,895	99 per cent.
Asst. professors	1,605	3,004	87 per cent.

MAXIMUM AND MINIMUM AVERAGE SALARIES AND INCREASES

	Max. 1900	Min. 1900	Max. 1925	Min. 1925	Per cent. increase Max.	Min.
Executives	$5,598	$2,050	$8,470	$5,562	208	0
Professors	4,002	1,958	7,008	4,550	161	44
Assoc. prof.	3,950	1,350	5,077	3,665	130	28
Asst. prof.	2,351	1,412	4,000	2,642	199	44

An examination of these statistics makes it clear that the economic position of professors in these universities is not so good in relation to other members of the community as it was in 1900. While the income of citizens, in gold dollars, has increased, on the average, about 200 per cent., that of these professors has increased less than 100 per cent. When we take account of the index numbers, the value of the salaries paid in 1925 was somewhat less than the value of the salaries paid to men of the same rank in 1900.

A report by Dr. W. Hardin Hughes, director of administrative research for the city schools of Pasadena, California, was published in August, 1929. It gives a very careful and exhaustive analysis of salaries paid in the city schools of Pasadena in 1928 in comparison with those paid to wage-earners in other callings. Dr. Hughes reports that in comparison with 1914, taking account of the index numbers, "the average income of all persons gainfully occupied in the United States in 1928 had actually gained 57 per cent. in purchasing power." This is in surprisingly close agreement with the conclusion reached above. It makes it quite clear that it is not fair to professors that their salaries should be increased merely in proportion to the change in the purchasing value of their salaries. The salaries should be increased in proportion to the increased income of the average citizen.

A concrete illustration will help us to see this. Since 1900 a very large proportion of the people of the United States have found it possible to own or use automobiles. This is one direction in which the 57 per cent. increase in the income of the average citizen is being used. We realize what an immense addition to the convenience and richness of our lives this has made. Is it not right that professors should be able to take advantage of these changes, as well as other citizens?

Men and women who take the degree of Ph.D. in chemistry go partly into industrial positions and partly into academic work. A comparison of the salaries paid to the two classes of individuals throws further light on the reasons why many of our most brilliant graduates do not follow academic careers.

During the years 1918 to 1928, inclusive, 146 men and women received the degree of Ph.D. in chemistry at the University of Illinois. In the fall of 1928 a letter was addressed to these graduates asking for a statement of the initial salary received after gradua-

tion and the salary received in 1928. Replies were received from all but three. Sixty-one engaged in academic work soon after graduation and have continued in such work. Fifty-three accepted and have continued in positions in industrial work. Fourteen entered academic work but left it for industrial positions. Two were in industrial work for a time but are now teaching. Thirteen have gone into medicine, hold fellowships, live in foreign countries or for other reasons can not be included in the average.

In academic positions, the average initial salary, including income from summer teaching or other work, was $2,407. For industrial work, the average initial salary was $2,845.

In 1928 the average salary of persons who had taught for four to ten years was $3,472. The average salary of persons who had held industrial positions for four to ten years was $5,619.

The highest initial salaries for academic work were one of $3,500 paid to a woman in a woman's college; $3,056, including summer teaching, paid to a man who returned for graduate work after some years of teaching, and $3,000. Two other incomes exceeding $3,000 included incomes from industrial work.

The highest salary for academic work in 1928 was $4,500, paid to a woman for teaching part time and doing executive work in a high school. The next two were $4,450 and $4,433, each including teaching in a summer school.

The three highest initial salaries paid for industrial work were $4,800, $4,000 and $3,840.

The highest salaries paid for industrial work in 1928 were $15,000, $13,000 and $11,000.

The University of Illinois offers courses in chemistry and in chemical engineering which require the study of chemistry for four years and include a minor amount of research during the senior year. An inquiry was directed to the graduates of these courses for the years 1919 and 1925. The results of this inquiry were not sufficiently extensive to justify a detailed report, but they indicate quite clearly that a man entering academic work with the degree of Ph.D., usually four to six years older than the man who takes a bachelor's degree, will receive, on the average, only about $400 more than the bachelor. Ten years later, the salary of the doctor in an academic position is, on the average, less than that of the bachelor in industrial work.

Chemists who are employed as teachers in our best colleges and universities are receiving far less than their fair share of the threefold producing power gained by the country during the last twenty-five years. Teachers who enter an academic career after receiving the degree of Ph.D. have, on the average, after five to ten years, a much smaller income than those who engage in industrial work.

It seems evident that unless these conditions can be remedied our universities must be content to fill their teaching positions with mediocre men.

The very slow increases in academic salaries are a just reason for complaint. We should seriously question whether the present policy of many universities to employ a much larger number of recently graduated doctors of philosophy than can hope for reasonably rapid promotion to salaries on which they can support a small family and care for their own professional needs for books and for attendance on professional gatherings is justifiable. Shall we not contribute more to the development of high standards by employing fewer people and giving more rapid and adequate promotion to those who are worthy?

During the last twenty years it has been necessary, repeatedly, to fill major positions in the department of chemistry at the University of Illinois. After looking the country over, with the aid of friends, it has often been found that the quest has narrowed down to only two or three who were suitable and possibly available at the salary which could be offered. Even then, it was found, on several occasions, that the men selected would not come. Sometimes the position was left vacant for a year and the search continued. In other cases the position was filled with a young man of unusual promise and he was then given a rather light load of teaching and allowed time and facilities for research which made it possible for him to make for himself a position of importance in the chemical world.

It is an open secret that Harvard University has tried very earnestly but has failed to secure a man of established reputation to fill the place of one who had grown up from the ranks to a position of international fame.

Professor Harper gave to the University of Chicago much of its initial prestige by calling a few men of national and international reputation at salaries of $7,500, which was much above any salary paid at that time in the middle west. To maintain a similar standard, to-day, the university should have a few professorships with salaries of at least $20,000. If some university will have the courage, to-day, to do this and to break away from that lock-step promotion, which is so fatal to the encouragement of men of exceptional ability, it will help to remove the very objectionable differences in rate of promotion in the universities and in the industries.

Dr. A. D. Little, who has built up a very strong organization of chemists working on industrial problems, permits me to quote him as saying that he has "found it advantageous and profitable to pay the

salaries necessary to secure men whose records lead their professors in the institutions they have attended to recommend them as exceptionally capable."

The great leaders in science have been men who were inspired by other great leaders who went before them. Liebig studied with Gay-Lussac, Wöhler with Berzelius, Faraday with Davy, Pupin with Helmholtz, Nef with Baeyer. The necessity of providing great leaders in our universities can not be overemphasized. To do this we must pay such men adequate salaries. It is, perhaps, of even greater importance that we should give young men of promise adequate time and facilities for research and that they should be promoted when they have shown their worth.

In a recent paper published in SCIENCE, the claim was made that salaries are inexorably fixed by the law of supply and demand and that it is useless to try to tamper with a law which the author of that paper seems to think is sacrosanct.

Such an attitude treats human beings as on the same level with the inanimate products of their labor. Sociologists are generally agreed that other factors beside supply and demand should be taken into account in determining wages and salaries.

Foremost among these is the "living wage" which is necessary to maintain the efficiency of the worker and enable him to provide suitably for those dependent on him. Surely the "living wage" for a professor should be on a higher plane than that of a day laborer. No one can do efficient work unless he is freed from the anxiety which comes from the attempt to make an inadequate salary cover the bare necessities of life. He should have a sufficient income to free him from that anxiety and to make it possible for him and his family to form reasonable social contacts with other cultured men and women. In addition to that he should be able to purchase the books which are the tools of his trade and to travel and associate, occasionally, with colleagues in his field, at home and abroad.

Henry Ford has recently stated a principle which he thinks should be considered by employers of labor. By increasing the wages paid to workmen their ability to purchase the products made by other workmen is increased. This is a recognition of the fact that under modern conditions production is limited, not so much by the number of workmen required and by the cost of machinery used, as by the market for the goods produced.

During the few years of the great war the position of the United States was changed from that of a debtor nation, with many of its securities held abroad, to that of the most powerful creditor nation in the world. This happened because we had the ability to speed up mass production and meet the emergencies of the war. The most important material losses of the war were not, as many suppose, the munitions and other materials used and destroyed, for these were almost entirely made during the war. The losses which have caused such a dislocation of economic relations are due to the transfer of wealth from one nation to another and from one class of citizens to another.

One of the lessons of the war which we should all learn and take to heart is that the people of the world are now able to make valuable products far more rapidly than the citizens of the world are able to buy them. If the salaries of professors could be doubled overnight, their scale of living would rise rapidly and they would furnish a market for products in such a manner that their increased receipts would mostly find their way back into the pockets of other citizens. In a sense, this is an illustration of the old saying, "Nothing succeeds like success." Henry Ford's principle is, within limits, essentially sound. In the long run, even on the rather low basis of economic prosperity, the use of the money of the people to increase the salaries of professors would contribute, materially, to the possibility of increased production and to the general prosperity of the country.

Another factor worthy of careful consideration is the value of the services rendered to the community. The increase in salaries which we are asking should not be considered as a charity to underpaid men and women. They should be considered as an attempt to pay a part of the debt which the community owes for the services professors render.

Liebig founded a laboratory which has transformed and democratized the teaching of science, not only in Germany but throughout the world. When Prince Albert wished to establish a scientific institute in London, he called to his aid Professor A. W. Hofmann, one of Liebig's students. The first of the coal-tar dyes was discovered and developed by W. H. Perkin, who studied with Hofmann.

The synthesis of alizarin, or turkey red, was discovered by Graebe and Liebermann, working in a German university. Germans did not, at that time, succeed in manufacturing the dye, but Perkin, with his experience in factory production, succeeded so well that as early as 1881 it was stated that the turkey red manufactured in one year was worth $8,000,000 but that it would have cost $28,000,000 to make the same amount from madder root, formerly used as the source of the dye.

In spite of this initial success in England, the manufacture of dyes was soon transferred almost completely to Germany. This happened because there were in Germany many young men trained in re-

search in laboratories similar to the one founded by Liebig.

Baeyer discovered a synthesis of indigo about 1880, and a manufacturing company worked for twenty years to convert the discovery to a commercial success. The company could not succeed till two other discoveries were added, one made by a professor in Holland and the other by a professor in Switzerland.

Professor Haber, formerly of Karlsruhe, developed the synthesis of ammonia from hydrogen and the nitrogen of the air. This discovery is destined to add greatly to the food resources of the world. Without it Germany would have been defeated in the great war in six months.

Michael Pupin is a graduate of Columbia, and he studied at the University of Cambridge and with Helmholtz in Berlin. He has done much to make long-distance telephony practically possible.

The first electrical manufacture of aluminum was invented by the Cowles brothers, students at the Case School of Applied Science in Cleveland. A second, more important, method was discovered by Hall as the result of a statement made by Professor Jewett in a lecture at Oberlin College.

Such illustrations could be multiplied by the thousand, and it would be easy to show that the wealth added by the work of professors in colleges and universities very far exceeds the cost of the maintenance of all these institutions.

The illustrations have been taken from chemistry and physics, but it would be a mistake to suppose that only scientific faculties are worthy of support. It is not necessary to argue the importance of training in other subjects than science. My own academic career was begun at Grinnell College, then a small western institution. There, Professor John Avery, who taught me Greek and German, was one of those who inspired me to a life of productive scholarship.

In conclusion, I wish to make the following practical suggestions.

(1) The executives of our colleges and universities should redouble their efforts to secure equitable salaries for their professors. They should see clearly that to secure able and efficient men in charge of the various departments and divisions of their work and so to relieve them from routine work that they may continue to be productive scholars as well as efficient teachers is the most important function of the institution.

(2) Positions as instructors should be given only to those young men, to be found anywhere in the country, who have the best training in the subject to be taught and who give most promise of becoming both efficient teachers and productive scholars. These requirements are more severe, in general, than the requirements for men who might succeed in industry, and the salaries should be rather higher than lower than the salaries paid for industrial work. In other words, executives should seek the best, not the cheapest.

(3) Such men after appointment should be given ample opportunities and time for productive scholarship and should also be encouraged to become efficient teachers.

(4) The number of instructors appointed should bear a close relation to the possibility of a rather rapid promotion for those who show exceptional ability.

(5) Lock-step promotion—a regular increase each year, almost irrespective of accomplishment—an easy device of executives to avoid trouble—should not be tolerated. Men of unusual ability should be promoted rapidly, as they are in the industries.

(6) New lines of work should be undertaken only when there are ample funds to support them. The California Institute of Technology set an admirable example when it refused to establish a department of biology before ample funds for its support were available without depleting the money needed for other departments.

ADEQUATE SALARIES FOR COLLEGE AND UNIVERSITY TEACHERS

By EDWARD A. FILENE

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I HAVE been asked to address this body upon the question of adequate salaries for university and college teachers. I have been asked to speak, however, upon only one phase of the question, that is, the social importance of such salaries. That immediately presents a difficulty, particularly to a business man. I confine my talking, usually, to business groups, and to tell the average business audience that something is socially important is not to tell it very much.

Every business man in America to-day knows that high wages for everybody are socially desirable. Not many of them know, however, just how they, individually, can make wages higher. They suppose that higher wages must be paid out of profits and, with

competition what it is, they do not feel justified in cutting their profits any thinner. For that reason, although I profoundly believe in raising wages, I never suggest to business groups that they ought to raise them. I tell them, rather, to raise their wages so that their total profits may be greater, and that is more likely to make a business man sit up and listen.

Now this attitude, I am perfectly aware, is likely to be resented by the scholarly mind. It is what is called "commercialism," and commercialism is supposed to be a very ignoble thing. If the attitude is studied, however, it may be discovered that it is not wholly unscientific.

The thing that impresses me most about scientists is that they are not so interested in what should be done as they are in what can be done. They do not care at all how electricity should act; they are simply curious to find out how it does act. They do not care what H_2O ought to be; they are anxious only to know what actually results when such a combination of gases occurs.

You would not permit a chemist to tell you that any formula should be adopted because the formula is socially important; hence, while I shall try my best to point out the social importance of adequate salaries in college and university research, I can not promise to separate the topic from the much more scientific theme of how salaries are raised.

You are doubtless familiar with the way in which educators got their living in the olden days. They attached themselves to lords and rulers and to wealthy patrons in a manner which, if you were to imitate it to-day, would lead to your being called a lot of grafters. They got their living in that way, however, because there was no other. They could not sell their philosophies to the poor, because in the first place the poor were altogether too overworked and tired to develop an appreciation for what the educator had to offer, and in the second place, the poor had no surplus with which to buy anything beyond their immediate physical necessities.

The great masses of people, it must be remembered, were always in poverty, although the masses created all the wealth. The accepted formula for becoming rich, in those days, was to take this wealth from the masses, generally through taxation; and he who was strong enough to wield the taxing power had the best chance of becoming wealthy.

It was a perfectly honorable proceeding. No one, not even the masses, questioned it. That it seems to us at this date to have been a very cruel order of society, and socially undesirable, is rather beside the point. It was the existing social order, and one had to live according to the laws governing that order or quit living. It was impossible, generally speaking, for people to support themselves and contribute much to the world's culture too. To secure a living through labor, one had to spend his whole time at it, and there was no time left for one to study and become a scholar. It was the mark of the scholar, then, that he was above soiling his hands with utilitarian toil, and the tradition has existed even to our times that the scholar is likely to be somewhat impractical.

But was the scholar ever impractical? Would it have been practical for him to spend his life in useful labor and thus make it impossible for him to attain any scholarship? The professors of old must have pondered that problem many times. They saw the injustices of the social order and many, like Plato, attempted to sketch an ideal human society. Saint Paul and the early apostles of Christianity, it is said, did try to support themselves by tent making and other handicrafts while they were carrying on their teachings, but unfortunately we have no record of how their economic scheme worked out. We know it was abandoned later, and the religious teachers of Christendom were supported by the church which, in turn, was generally supported by taxation.

In China, where the ancient patriarchal order endured right up to the present time, it was everywhere accepted that the scholar should do no work: and usually he grew finger-nails six inches long as a demonstration to whom it might concern that he would not and could not use his hands. Others, of course, had to work all the harder in order to free these scholarly gentlemen to develop their scholarship and their finger-nails. But those who worked did not resent it. The world, they seemed to have perceived, could not get along without education, and many a family whose members for generations were doomed to live out their lives in poverty and toil still imposed a voluntary tax upon themselves in order that some one member of their family every hundred years or so might become a scholar and thus bring honor to the family.

I do not wish to philosophize upon the theory or the traditions of education. I wish simply to point out that there was a good sound scientific reason for the tradition that the educator should be above the ordinary scramble for wealth. Never, however, was he or could he be aloof from the economic system. Unless there were leisure, there could be no education and culture; and those who specialized in education and culture were generally practical enough to abstain from practical affairs. The educators, whether they fully understood what they were doing or not, did adjust themselves to the existing economic order, and only when the economic order changed did the educational order change.

In the purely patriarchal order of society, before

the days of cities and of wide-spread trade, about the only education which a child could get was that which he received within the family. It was about all he needed, for education consists, very largely at least, of an understanding and appreciation of one's relations to the things outside of himself; and in the family order, his family relationships and his relationship to his family's gods constituted about all the relationships which he could comprehend. People got almost their entire living from the land on which they squatted, and they did almost all their living then within that small community of squatters. If a child learned the full meaning, then, of father and mother and brothers and sisters, and if he learned how to do the things which it was necessary to do if the family was to be a going concern, he was properly accounted wise.

When trade began to develop, however, and families, instead of getting their whole living by applying their own labor to their own land, found it more advantageous to exchange a surplus in some line for some other family's surplus in another line, new human relationships were set up and a new education dawned. For, with the development of trade, there had to be trade routes and trade centers, and in these trade centers, people of very different traditions brushed up against each other and learned each other's traditions and each other's languages and each other's arts and handicrafts. They became sophisticated, and out of this sophistication the literature and the arts of the cities were evolved. There was no discernible evolution of the human brain, but there was a perceptible evolution of human understanding, calling for teachers of a decidedly new type. These teachers held aloof from trade, but they adapted themselves admirably to the economic and social structure which trade had built.

It was necessary that these far-flung trade routes have some traffic regulation. It was necessary that they be policed, if there was to be any semblance of order, and so the imperial state came into existence. This state required statesmanship—trained statesmanship—and presented a new field for educators, so education, again, had to follow the economic trend.

It was necessary, even, that the religions be revised. The old family gods, which had been perfectly adequate in a patriarchal society, would hardly do for an empire claiming dominion over the whole known world. Many attribute the rise of Christianity in the Roman empire to this need of the times for a god who wouldn't have to be carted around, but who could be depended upon to rule everywhere and take charge of every last detail of this highly complex world as the old Lares and Penates took charge of the ancient family affairs.

I am not a historian and do not know how far to accept the theory. It is obvious, however, that the rise of Christianity did not mean that all Europe had become suddenly converted to the idea of universal love. It is also obvious that the new religion was a state religion, and it remained everywhere a state religion until new economic forces began to assert themselves. It is worth noticing, moreover, that, wherever the state was the supreme economic power and the church and the state were looked upon as one, the church took charge of education, and out of the monasteries grew the universities.

With the coming of the first Industrial Revolution and the rise of what we know as "capitalism," education took a still different course. This course was made necessary by the new economic set-up, although few, if any, perceived the exact connection. This is not strange, for the capitalists did not think of capitalism as a new social order. They thought of it as a new way for individuals to get rich, providing the state and the nobility and the other traditional institutions would keep out of their way. The right of the individual loomed up as the controlling principle, and it was preposterous, people began to say, that one's status in life should be fixed by his birth or breeding. There was no conscious rebellion against the institution of the family. People expected to go on just as they had always gone on, excepting that one man would have equal rights before the law with any other; and wherever the new factory system became highly developed, there was a tendency toward democracy. The state was given charge of education, with the understanding that the state should be guided at all times by the consensus of the free and independent citizens.

Here was something of a predicament. It was bad enough, in the old days, when kings and ministers and ecclesiastic specialists assumed from time to time to tell the teachers just what they should teach. But now the theory was set up that the ignorant masses should stipulate just what and just how they should be taught. The theory, however, untenable as it may be, has died hard. The late Mr. Bryan gave voice to it when he argued that the taxpayers had a right to decide as to what is or is not correct biology.

Whether the taxpayers should or should not control education is, fortunately, a question which need not be discussed. For the point is, they can't. They may prohibit education. They make take measures to organize the school system so that the truth about things may be kept from the knowledge of the students. But they can not say what shall be taught. Much as they may try to do it, it can't be done, for the moment the schools set out to tell students what

to think they cease to be an educational force in these modern times.

That statement needs examination, for the schools of the past surely did attempt to tell their students what to think—at least, many of them did, and they were still educational institutions. How does it happen that what was true once is no longer true?

You know the answer. What happened was modern science. After modern science got under way in human affairs, telling people what to think ceased to have the educational value which it had had before. For the world, up to this modern scientific era, had been governed by authority, that is, by the opinion of its rulers and its ruling classes. Class rule, in fact, was the only rule possible. If there was to be any culture, if there was to be any expansion of knowledge, if there was to be any human progress from generation to generation, it was necessary that the human mind and the human spirit be relieved, somehow, from the deadening influence of toil. It was necessary that there should be leisure, but it was impossible that there should be leisure for many, and if there were leisure for a few it could be attained only at the expense of putting upon the overburdened masses still heavier burdens yet.

Such an organization of society could not exist along with any theory of equality. There had to be special privileges, and the masses of people had to be taught to believe in the divine right of the privileged classes to exploit them, and only when the process was carried on to a humanly unendurable point was there ever much rebellion.

Capitalism ushered in modern democracy, not because the capitalists were philosophers who had reached the conclusion that special privileges were wrong, but because the special privileges of the landed aristocracy interfered with their individual schemes for getting rich. The capitalists did not consider themselves a class. Each capitalist was likely to look upon every other capitalist as his competitor, whom he would like very much to put out of business entirely. But he wanted to be free to do it, and only through exalting individual rights could he see that any free-for-all fight would be possible. The capitalist did not believe for a minute that his interests were the same as the interests of the masses. He did not believe that the interests of capital and labor were identical; he supposed, in fact, that it was to his interest to buy his labor in the cheapest possible market and that his best chance of success lay in the economic failure of his employees.

Moreover, the capitalists did not know that anything fundamental had happened to alter the age-old system of government by opinion. They did not understand what the dawn of modern science meant, and that man hereafter must live less and less according to the way in which he was told to live, and more and more according to the facts which it was possible for him to find.

They made no war against tradition, the only traditions to which they objected being those which stood in the way of their getting rich. In fact, those are about the only traditions which the world has ever rejected—those traditions which stand in the way of our economic interests. It is easier, generally, to accept a tradition than to think it through, and if people think that they can afford to accept it they will. Women, for instance, for thousands of years, obediently and complacently married the men whom their parents selected for them, because they couldn't afford to do otherwise; but women are very different creatures, now that they can afford to be.

I am not trying to give you an erudite account of the history of civilization. I am speaking, remember, purely as a business man. As a business man, I discovered that the so-called rules of business would not work. I discovered, to my cost at times, that the traditions of business were all out of plumb with its realities. I discovered particularly, as thousands of other American business men have been compelled to discover, that even my own opinions were not valid. We discovered, in the end, that business can not be run successfully on any one's opinion, but that, if we were to meet and beat competition, we would have to conduct our business upon actual scientific research.

This did not make me a scientist, but it compelled me to look into the matter of what science had been doing to human affairs. I had supposed, in my ignorance, that its main contribution had been the mere increase of knowledge—information which alert business men might make use of now and then. But I discovered that it was changing our whole approach to human life. It was not only breaking down certain traditions, but was arraying itself against all traditional thinking. It was making it increasingly impossible for class rule to go on and for human affairs to be determined by the opinion of some ruling class. Nor could the opinion of the majority be substituted, for when science made a discovery the discovery was not affected in the least by the election returns.

The old authorities, it seemed clear, were gone. The family, which had gained its authority through its economic dominance, was now losing its influence. Ecclesiasticism was also passing along with the whole theory of the divine right of minorities or majorities to tell us what to think. The truth, it was evident, no longer came from authority, but authority came only from the truth.

You are as familiar as I am with the change which has come over all human society since business began

to shed its traditional opinions and adopted the methods of scientific research. No comparable change has ever happened in all human history in so short a time. But how this change affects the status of the teachers in our colleges and universities is the object of our special inquiry here. The traditions of education and the traditions of business may be as far apart as the poles, but the truths of education and the truths of business can not be contradictory. In the age of authority, of necessity I believe, educators had to effect some working alliance with the authorities. Doubtless they believed what they taught, and doubtless, also, the things that they taught were for the ultimate human good, however hard they might bear upon the masses in their generation. Educators in the ancient days could not proclaim liberty and equality and fraternity, for there was nothing in the economic set-up which made liberty and equality and fraternity possible. About the most they could do, then, in the way of alleviating the anguish of human life, was to teach the privileged classes to be just and merciful, and to give of their bounty to the poor. They may have felt themselves above economic considerations, but when education was necessarily confined to a small leisure class they could not be.

To be educated in the old days meant to be "well read," for the knowledge of the world was pretty well outlined in a number of books which it was possible for an exceptional mind to read and digest in a lifetime, if he had sufficient leisure to devote himself to the task. Hence it was quite natural, with the rise of democracy, that there be an attempt to make education universal so that everybody in the end might become well read. But those who were hoping along these lines failed to take note of what science had been doing. Science had been digging up new knowledge, and it had been digging up so much new knowledge that it had become impossible for any individual brain to absorb even the gist of it.

Little by little, then, the educators had to abandon the theory of a general education. Grudgingly, and with an agonizing tug at their traditions, they accepted specialization. One reason why they accepted it was that a knowledge of the ancient classics had struck a bear market, while there was an ever-growing demand for a knowledge of the new chemistry.

Weak opportunists in the educational field surrendered at once, and were quite willing, in return for fat endowments, to reorganize their colleges according to the new bourgeois demand. They admitted wealthy business men of no academic standing whatever to their directorates. These business men were supposed to be practical, but their course was such as to dismay the faithful old guard of college professors who were trying to live up to the best academic traditions and believed that education should be superior to money-making.

I hold no brief for either side. I am simply trying to state the situation. Unless the situation is understood, unless we can trace the forces which are reshaping human society and all its institutions, there is little likelihood of our solving the problem of college and university salaries. Those salaries are going up. I can say that confidently, and I can tell you why; but they will not go up rapidly enough, or in an orderly and systematic and satisfactory manner, unless the teachers themselves fully grasp the situation and deal constructively with it.

When business men began to control our institutions of higher education it might be supposed that they would alter them in accordance with the business needs of the day. But that is only a supposition based possibly on the supposition that, because a man had succeeded in business, he must know a great deal about business needs. There is little ground for this assumption, for until very recently, business was not governed by scientific fact-finding but by the opinion of the chief executive, and while this opinion was always affected by his business experience, it was almost uniformly grounded in tradition. If a man succeeded in business, then, it was not because he knew scientifically what he was doing, but because his opinion happened to be a little nearer the mark than the opinions of his competitors. But even if his opinions were good in the particular field to which his life had been devoted, this did not insure his having good opinions in other fields. If he had customarily asserted his good opinions strongly in his business, however, it was almost a foregone conclusion that he would assert his opinions quite as strongly elsewhere, whether he had any grounds for his opinions or not. This is a mere habit of human nature. It is part of the pompousness that comes from success.

But that type of business leader is going. He is going because business has discovered a safer and more efficient leadership—the leadership of scientific research. The great executive of to-day, when confronted with a business problem, does not give the answer to it. He *finds* the answer instead. He knows, of course, that he is unequipped personally to find these answers. They must be found by research specialists in scores of special lines; and every year, therefore, the demand is increasing for men and women trained in scientific thinking.

The great system of mass production which now dominates the market was developed by such thinking, and depends upon scientific research for its daily pro-

grams. And because it is dominating the market, all business must adopt its methods. In the very near future, then, there will be such a demand for fact-finders that our colleges and universities will be hard put to it to furnish an adequate supply, and those who are most capable of teaching and training our youth to become fact-finders will be tempted by large salaries away from the colleges and universities into business and industrial life.

I hope, when that time comes, that our teachers will prove to be sufficiently selfish. If they are unselfish, if they are willing to sacrifice themselves and their families to the traditions of education and go on teaching in college while their wives do the family washing, we may be in for considerable trouble; but if they are sufficiently selfish, as I have reason to believe they will be, it will be up to the colleges to find a way to keep them from accepting the offers which they get. And the only way that they can find will be through raising their salaries—not to a mere living wage but to several times beyond their present level.

And how will the colleges be able to do this? The answer is that they will do it by continuing the seemingly deplorable course upon which they started some time ago, making closer and closer connections with the business world.

But this time they will not be trading their academic ideals for fat endowments and elevating ignorant and opinionated business leaders to their directorates because they are rich. For the leaders of the new industrial order, while they may be ignorant, can not be opinionated. They must be men who are willing and eager to learn, who hold the positions they hold because they are eager and willing to learn, and who have at least learned one fundamental truth —that the best way to decide whether any course is right or wrong is to find out.

Schooled or unschooled, then, they will not wish to shape the colleges to their preconceived opinions. They will put them, if they can, upon a fact-finding basis; and when it is discovered that the colleges are losing their best men because they are not being adequately paid, the answer to that will be adequate salaries.

It may seem to some that I am suggesting an unconditional surrender of educational ideals to the economic necessities of the moment. I am not. But the problem, I wish to emphasize, is not one of whether education shall remain aloof from economic change or be guided by it, for education can not remain aloof from economic change: it is impossible that education shall develop in one direction while human relations are developing in another. The problem for the teachers, as I see it, is whether they shall accept the facts of economic change, in the same way that they accept the facts of chemistry and physics, and organize their understanding and their activities in accordance with those facts, or whether they shall be driven blindly into positions which seem to be at variance with their academic ideals.

For I am not talking about what ought to happen. I am talking about what is happening now and what, because of forces which are so actively at work among us, must happen more and more.

Thousands of teachers to-day, especially in our larger cities, are eking out their salaries with part-time commercial employment. Many of them resent the necessity for this. They would rather, they think, be liberated to teach pure truth, than have to go into the world of business and discover from day to day what the pure truth about that world is. I can sympathize somewhat with their resentment; nevertheless, it is one of the best signs of our times that the teachers of our youth all over the country are getting this practical first-hand knowledge and keeping the educational and the business orders within communicating distance. If they are not kept within communicating distance, we know, one or the other must soon fade out of the picture, and it will not be the economic order that will go. Every such tie-up, then, is of direct practical value to the colleges and universities. If there are seeming clashes between the truths of education and the truths of business, it will do no good for educators and business men to try to argue it out. Educators know this, and business men, I am glad to say, are beginning to know it. They are beginning to know that, when problems arise, the only dependable course is to discover the facts.

What is most necessary now is that this unconscious and disorderly movement to blend education and industry become conscious and orderly. The schools must perceive the necessity of fusing with our new economic order, and our industrial civilization must perceive the necessity of building up, within itself, a genuine educational and cultural life.

Teachers, then, of all people, must of necessity learn the facts of our changing economic order; and when those facts are learned, I feel very certain much of the resentment against "commercialism" will disappear.

For this machine civilization is not at all what its very leaders have traditionally supposed it was. It is not the creation of supermen or of business geniuses. It is a simple matter of science and power coming into very ordinary human brains and hands. Science discovered the power. Ignorance has used

it, to be sure, to our individual and social undoing, but the great historical event of our times is that it has been discovered that this power can not be successfully used in anything less than the scientific way and that the scientific way to use it has proved to be the way of maximum service and maximum total profits.

When man began to use it, he supposed that he could use it at the expense of others. Now, not because he has had a change of heart, he is beginning to learn that this can not be done. Time was when men could get rich in business through exploiting their fellow men on every hand. Some may seem to be doing that to-day, but the game is almost played out, for the markets of the world are fast becoming dominated by those industrial and commercial institutions which are scientifically discovering how to give more service for the money than has ever been given before.

Time was, not so long ago, when high prices were supposed to mean large profits. There was a reason for such a belief, for it was universally perceived, before power came into the world, that the masses of people could not possibly buy the beautiful and luxurious things with which business most concerned itself.

But mass production has changed all that. Mass production means production for the masses. Unless the masses can buy, mass production, with all its economies, can not go on. Therefore, mass production, which already dominates our markets, insists—for scientific rather than sentimental reasons—that the masses be equipped with buying power, and by the use of science in methods and in management has discovered how production may be so increased per man that these higher wages may be paid.

The ancient theory of business was to add a profit to the cost of production, however great the cost of production was, and search for the few customers with sufficient buying power to pay such a price. The new principle is to set a price which the masses can pay, and then to enlist all the available science in the world to discover how the thing may be produced and sold at a profit within that price.

This second Industrial Revolution is the greatest revolution in human history. All previous revolutions meant the ascendancy of some new class over the previous ruling class. This revolution means the ascendancy of science and the liberation of the masses, not merely from the tyranny of some ruling class, but from the devastating influences of poverty and toil. I grant that the masses are still ignorant, and that universal literacy has not meant, and could not mean, universal education. Even if it were possible for all to read the classics and to recite them glibly in the original Latin and Greek, still there would not be universal education. For education consists, largely at least, of an understanding and appreciation of our relation to the things outside ourselves, and the ancient classical curriculum can not give us that. Only as we learn the truth, including the truth about life as it is and as it is becoming, will the truth make us free to live a larger life.

The machine civilization not only needs this truth but is rapidly becoming conscious of the need. Business needs fact-finders, and is employing them more and more. Also it needs fact-finders with adequate equipment and adequate buying power. And it needs fact-finders not only in the realm of chemistry and physics but in every science which points a way to a larger human life.

Business in the near future must come to realize that it needs psychologists quite as definitely as it needs engineers, and sociologists quite as much as economists. Not only must business be freed from traditional thinking, if it is to meet the scientific competition of to-day, but the masses whom it serves must be freed from traditional thinking if they are to function adequately in this new world order.

This new economic system can not afford war, and it can not afford the narrowness and provincialism which engender it. It can not afford ugliness, or that deadening contentment which the ruling classes once insisted that the masses should cultivate. As leisure increases and buying power increases, there must be a corresponding increase in ambition for and appreciation of the good things of life. Taste and culture then must be developed. The emotions must be educated and there must be a greater and greater development of the spiritual values as this supposedly materialistic machine civilization goes on to its logical destiny.

I have said often, to business audiences, that the pursuit of beauty is the greatest thing in human life. It always was the greatest thing, but now we have hit upon times when the masses of humanity everywhere can and must engage in that pursuit. The pursuit, however, must be along fact-finding lines. The new order can not be discovered in the old traditions. It must be discovered in the new relationships, and the time of the discovery will depend very largely upon the willingness of our educators to break from the old tradition of aloofness and enter into joyous, whole-hearted, enthusiastic and constructive cooperation with this new, fact-finding, economic system.

If this be commercialism, make the most of it.

DISCUSSION

A WRITER in *Science Progress*[1] some years ago expressed the opinion that the pretense that the man of science is above cash in any form is perhaps the worst form of scientific snobbery. "In science as in other things," said this writer, "the proper and honest procedure is to pay for work done." This form of scientific snobbery, now rapidly and most fortunately disappearing, did not fool the clear-headed among business men. The late E. W. Scripps, one of the founders of the Scripps chain of newspapers and of *Science Service,* regarded scientists who willingly and unnecessarily labored on a miserable stipend as economic imbeciles. A biologist might have said that such scientists were not well adapted to their environment. Adaptation is likely to be the key to survival of scientists as well as other organisms.

It is common knowledge that scientific research in a single century has outstripped the experience of ages. Dr. Cattell is authority for the statement that science has increased wealth fourfold, an assertion very easy to believe. The same leader points out that democracy is dependent on science.

The "fiat currency of honor and position" does not pay the bills, even for personal and official scientific advancement. Peixotto's studies at California indicate that the average expenditure of ninety-six faculty men for professional advancement was only 1.3 per cent. of salary, and twenty-two of them spent less than one half of one per cent. Henderson in a similar study at Yale found that two thirds of the faculty had to supplement their regular university salary by outside work, and that in some instances the professors could not even afford to send their children to a college of the grade in which they themselves were teaching.

It is perhaps unfortunate that the world does not "seek out its benefactors and voluntarily offer them the reward to which they are entitled." Breuer[2] rightly says, "The physician's primary duty is to provide a comfortable existence for himself and his dependents. That comes even before his duty to his fellow man for the simple reason that he can not do his fellow man much real good unless he is properly equipped."

According to Professor Compton there was in 1927 no university in America, land of wealth and opportunity, which was able to offer, dollar for dollar, a salary equal to salaries in universities even in war-ridden Germany.

J. S. Ames, now president of the Johns Hopkins University, asserted,[3] "The scientific men of America have suffered greatly at the hands of the people." The significant statistics presented by Professor Noyes at the symposium on the salary question, arranged by the Committee of One Hundred on Scientific Research of the American Association for the Advancement of Science at Des Moines, Iowa, December 31, 1929, amply substantiate President Ames' statement. To quote Ames further: "The time has come for America to recognize the usefulness of the scholar, the thinker, the investigator of science. All the other countries of the world have done so long since."

SCIENCE[4] quotes the British Committee of the Privy Council for Scientific and Industrial Research to the effect that all the important advances which recent generations have made in industrial science, from wireless telegraphy to synthetic indigo, have been the direct outcome of discoveries made by "pure" science conducting research solely for its own sake. The committee also emphasizes the necessity for a let-up on competition, and for more cooperation, and concludes that "it is not an accident that the firms which have been most conspicuous in the world for their scientific advances—such as the Carl Zeiss firm of Jena—have also been most conspicuous for enlightened and generous conditions of employment."

The importance of science to civilization requires that intellectual ability of the highest order should be recruited, developed and devoted to research—ability certainly equal or superior to that of the foremost captains of industry. The experience and testimony of our leaders indicate unequivocally that there is a high degree of correlation between salaries and standards of performance.

In 1926 Professor William MacDonald said, "We might have had the needed endowments long ago if intellectual workers, recognizing their solidarity, had unitedly asked for them; we can have them now whenever the workers are prepared to use them and ask for them with common voice."

There used to be an idea among some scientists, now happily dissipating, that organization for economic advancement would hamper individuality, would tend to mediocrity of performance. The accumulating experience of actors, physicians, professors, lawyers and engineers unmistakably indicates that this is not the case. On the contrary, organization, by providing the benefits of contact, united effort, more adequate salaries, superior facilities for work and improved status, gives freer play to the expression of individual abilities and tends to strengthen all inventive and investigative efforts.

[1] Quoted in SCIENCE, May 4, 1917, pp. 433–435.
[2] *Medical Economics,* April, 1924, pp. 17–19.
[3] SCIENCE, October 5, 1918, pp. 401–410.
[4] November 3, 1916, pp. 641–642.

Scientific men are working together increasingly along economic lines, not to control anything or anybody, but to secure that status which will enable research men to do their best for society.

The Committee of One Hundred on Scientific Research of the American Association for the Advancement of Science is doing a notable service to all scientific men and to the community. Special credit is due to President Millikan, and to Messrs. Cattell, Kellogg, Pupin, Livingston and True, members of the Executive Committee of the Committee of One Hundred. The efforts of the council and the Executive Committee of the association in supporting the work of this committee also deserve appreciation. Most of the work of the Committee of One Hundred has fallen on Dr. Rodney H. True, head of the department of botany and director of the Botanic Garden at the University of Pennsylvania, whose tireless efforts as secretary of the committee are well known to those who have worked close to him.

The work of the Committee of One Hundred has been done in the spirit of a statement made by Sir John Russell referring to research in agriculture:

> The past has been rich in the joys and thrills of discovery; but it has taught this lesson: that discoveries in applied science inevitably follow advances in pure science. If we would improve our agriculture the surest way is to increase knowledge of the soil, the plant and the animal. Empirical methods, it is true, have often given advances in the past, but they are slow, hesitant and uncertain; dependent on accident. Exact knowledge is the only sure basis for improvements; encourage, therefore, those among you who are striving to win it.

WALTER P. TAYLOR

NATIONAL FEDERATION OF FEDERAL EMPLOYEES

OBITUARY

RECENT DEATHS

DR. WILLIAM E. STORY, professor of mathematics at Clark University from its foundation in 1889 to 1921, and since then professor emeritus, died on April 11. He would have been eighty years old on April 29.

DR. FRANK HAIMBACH, assistant curator of entomology at the Academy of Natural Sciences, Philadelphia, has died at the age of seventy years.

DR. FRANZ C. WALDECKER, director of chemical research at the Winthrop Chemical Company, Inc., and the H. A. Metz Laboratories, Inc., died recently in London. He was forty-eight years old.

PROFESSOR JOHN OLIVER ARNOLD, F.R.S., emeritus professor of metallurgy in the University of Sheffield, died on March 27 in his seventy-third year. He was a pioneer in work on vanadium and molybdenum.

THE death at the age of sixty-four years is announced of Professor R. Zsigmondy, holder of the Nobel prize for 1926, professor of chemistry at the University of Göttingen.

THE death is announced of Dr. Hermann von Ihering, professor of zoology in the University of Giessen.

DR. KATSUSABURO YAMAGIWA, professor of pathology at the Tokyo Imperial University, Japan, died on March 2. He specialized in the experimental study of cancer. The production of tar cancer in rabbits was one of his outstanding accomplishments.

MEMORIALS

A TABLET in memory of Bashford Dean was unveiled on April 14 in the hall of armor at the Metropolitan Museum of Art. The tablet is the gift of the sculptor Daniel Chester French. Dr. Dean was at the time of his death honorary curator of arms and armor at the Metropolitan Museum as well as honorary curator in the American Museum of Natural History and professor of zoology at Columbia University.

THE *Journal* of the American Medical Association reports that the physicians at Fukushima, the native place of the late Dr. Hideyo Noguchi, have erected in his honor a stone monument in the garden of his old house on Lake Inawashiro, and the house has been bought to be kept forever in his memory. A library will be established near the house.

The British Medical Journal writes editorially: "Jean Baptiste Lamarck, soldier, biologist and philosopher, was born in Picardy in 1744, and died in 1829. His remains lie buried in an anonymous grave in Montparnasse cemetery, Paris, but until 1914 his native country had a memorial of him in the house where he was born, the home of his ancestors at Bazentin, a small village of the Somme, not far from Albert. During the war years Bazentin lay within the war zone, and now what was Lamarck's house is but a heap of ruins. The Société Linnéenne du Nord de la France has resolved to raise a fund to be used for the purpose of erecting on the site of the old house a memorial worthy of Lamarck's greatness. This memorial will stand in the middle of a garden in which the plants grown will be the botanical species specially studied by Lamarck, or named after him by other botanists. Lamarck belongs not only to his own province and country, but to all countries whose cul-

ture has been influenced by his pioneer work; and the society feels, therefore, that to help it in its project it may call on the members of the great scientific brotherhood throughout the world. It extends its appeal to the scientific societies of the British Isles, and asks that all remittances by check or international postal order should be directed to the account of the Société Linnéenne at the Banque de France, succursale d'Amiens (Somme), and ear-marked for the Lamarck Fund. Letters should be sent to M. le Secrétaire Général du Comité Lamarck, 81, rue Lemerchier à Amiens, Somme."

SCIENTIFIC EVENTS

GIFT OF CRYSTAL TO THE SMITHSONIAN INSTITUTION AS A MEMORIAL TO WORCESTER REED WARNER

THE Smithsonian Institution announces that a perfect sphere of flawless crystal, believed to be the largest in the world, is now the property of the United States National Museum, thanks to the generosity of Mrs. Worcester Reed Warner. Mrs. Warner made the gift as a memorial to her late husband, whose own outstanding achievements were largely in the manufacture of astronomical instruments from quartz.

The crystal ball measures 12⅞ inches in diameter and weighs 106¾ pounds. Perfect spheres of as much as 6 inches in diameter are great rarities, prized alike by emperors and museums, so that the uniqueness of the National Museum's acquisition may be realized.

The block of quartz from which the ball was cut is said to have come from Burma and must have weighed over 1,000 pounds. It was cut in China and polished in Japan. Eighteen months were required for this delicate and laborious task. According to Mr. George F. Kunz, the Japanese workmen first round the rough mass of crystal by careful chipping with a small steel hammer, forming a perfect sphere with the aid of this tool alone. For grinding they use cylindrical pieces of cast iron, about a foot in length and full of perforations, in which the ball is kept constantly turning. The abrasive material used in this first grinding is powdered emery and garnet. The final polishing is effected with crocus or rouge (finely divided hematite), giving a splendid lustrous surface.

The ball came to this country in 1925 and was immediately placed on temporary deposit in the National Museum. The officials of that institution express their pleasure that Mrs. Warner's gift makes it the permanent property of the nation. The late Mr. Warner, to whom the gift is a memorial, was a member of the firm of Warner and Swasey, instrument makers. Mr. Warner designed and constructed three of the largest telescopes in use in this hemisphere, including the 36-inch instrument of the Lick Observatory, the 40-inch telescope of the Yerkes Observatory and the 72-inch telescope for the Dominion of Canada.

FELLOWSHIPS IN CHEMISTRY AT THE JOHNS HOPKINS UNIVERSITY

THE Department of Chemistry of the Johns Hopkins University has announced the second annual quota of fellows selected under the National Fellowship Plan established last year. The plan provides ultimately for the establishment of one fellowship from each of the forty-eight states of the union. There are in addition two national fellowships-at-large and one international fellowship for England.

In announcing the names of the newly elected fellows, Dr. J. C. W. Frazer asked that it again be emphasized that the chemical fellowship plan at the Johns Hopkins University does not contemplate the discovery of chemical geniuses nor the production of "super-chemists." "The plan is in effect," he said, "an experiment in chemical education which puts into actual operation a few ideas which are almost universally endorsed but too seldom concretely applied. The unique feature of the situation is that careful planning on the part of the university officials and generous cooperation from public-spirited individuals and organizations have made it possible to remove many of the practical difficulties which often stand in the way of 'ideal' procedure."

The fellows newly selected by the respective state committees are as follows:

William Shallcross Speed Fellowship: Thomas Cross, Jr., University of Kentucky, Lexington.

U. S. Industrial Alcohol Co. Fellowship: Donald L. Zink, Louisiana State University, Baton Rouge.

General Motors Corporation Research Laboratories Fellowship: Arthur L. Glasebrook, University of Michigan, Ann Arbor.

Hormel Foundation Fellowship: Walter O. Lundberg, University of Minnesota, Minneapolis.

G. A. Pfeiffer Fellowship: Lloyd B. Thomas, University of Missouri, Columbia.

John M. Hancock Fellowship: Donald L. Farnham, University of North Dakota, Grand Forks.

John Wiley and Sons, Incorporated, Fellowship: Donald A. Wilson, Geneva College, Beaver Falls, Pennsylvania.

Du Pont Fellowship: Clarence P. Ely, University of Richmond, Virginia.

Fleischmann Fellowship: William Redmond Johnston, University of Washington, Seattle.

Carbide and Carbon Chemicals Corporation Fellowship: Henry C. Chitwood, West Virginia University, Morgantown.

Patrick Garvan Memorial Fellowship-at-large: Theodore L. Brownyard, Massachusetts Institute of Technology, Cambridge.

The English fellowship will not be awarded until later in the year.

Each fellow receives one thousand dollars annually while studying for his degree at the Johns Hopkins University.

The course of instruction outlined for them emphasizes fundamental training in mathematics, physics and English, as well as in the four major branches of chemistry (inorganic, organic, physical and analytical). A broad fundamental training is the objective.

The plan also provides for contact with prominent chemists, both American and foreign, under a special lectureship established by Dr. A. R. L. Dohme, of Sharpe and Dohme.

To date twenty-five fellowships have been established. They are as follows:

Eli Lilly Company, Indianapolis, Indiana.
Firestone Tire and Rubber Company, Akron, Ohio.
Francis P. Garvan, given at-large.
J. T. Baker Chemical Company, Phillipsburg, New Jersey.
H. A. B. Dunning, Baltimore, Maryland.
The Bill Raskob Foundation, Wilmington, Delaware.
The Brown Company, Berlin, New Hampshire.
The Brown Company, Portland, Maine.
The Kewaunee Manufacturing Company, Kewaunee, Wisconsin.
The General Motors Corporation Research Laboratories, Detroit, Michigan.
The Carbide and Carbon Chemicals Corporation, West Virginia.
The Fleischmann Company, Washington.
William Shallcross Speed, Louisville, Kentucky.
Patrick Garvan, given at-large.
Mary Carroll Garvan, given at-large.
John Wiley and Sons, Incorporated, Pennsylvania.
U. S. Industrial Alcohol Company, Louisiana.
Hormel Foundation, Austin, Minnesota.
E. I. du Pont de Nemours & Company, Virginia.
John M. Hancock, North Dakota.
Frederick G. Donnan, England.
G. A. Pfeiffer, Missouri.
American Can Company, California.
American Can Company, Oregon.
American Can Company, Utah.

SUMMER MEETING OF THE BOTANICAL SOCIETY OF AMERICA

THE informal summer meetings held last summer at Dartmouth College, Hanover, New Hampshire, and at the University of Wyoming, at Laramie, Wyoming, met with such warm appreciation by those who were present that the society decided at its last meeting to arrange for one or more such meetings for the coming summer. Preliminary inquiries developed the fact that a large number of botanists will be in England and elsewhere and it seemed best in view of this wholesale migration to hold but one meeting. It seemed that this might be a good time to accept the cordial invitation from the University of Washington, Seattle, to meet at the Biological Station of that university, Friday Harbor, on Puget Sound.

Here exceptional opportunities will be offered for observing the giant algae of the Pacific and the otherwise rich vegetation of the Sound. Proximity to lumbering operations as carried on among the large trees of the northwest as well as to glaciers on Mt. Rainier or Mt. Baker offers other interesting possibilities.

Round-table talks as general subjects and impromptu discussions as personal associations may suggest will give the same informality to the meeting that characterized those of last year.

A hearty welcome will meet all botanists whether members of the society or not. Colleagues from other countries are cordially invited to be present.

A circular giving more detailed information will be mailed to members of the society in May.

Meanwhile, inquiries may be addressed to Professor T. C. Frye, Botanical Department, University of Washington, Seattle, Washington.

RODNEY H. TRUE,
Chairman of the Organizing Committee

CELEBRATION IN HONOR OF DR. WELCH

A DISTINGUISHED audience gathered in Memorial Continental Hall, Washington, D. C., on April 8, to celebrate the eightieth birthday of Dr. William H. Welch, professor of the history of medicine at the Johns Hopkins University.

The address made by President Hoover was transmitted by international radio and meetings had been arranged in many American and foreign cities. The program included speeches by the President; Dr. Livingston Farrand, president of Cornell University, and Dr. Simon Flexner, director of the Rockefeller Institute for Medical Research; reading of congratulatory messages by John A. Kingsbury, of the Milbank Memorial Fund, and the presentation of the first impression of a dry-point etching of Dr. Welch by Alfred Hutty.

President Hoover's address was as follows:

The many years that I have been honored with Dr. Welch's friendship make it a privilege to join in this day of tribute to him by his friends, and by the great scientific societies of our country and the whole world.

Dr. Welch has reached his eightieth year, and a whole nation joins in good wishes to him.

Dr. Welch is our greatest statesman in the field of public health, and his public service to the nation well warrants our appreciation of him. With profound knowledge, wide experience and skill in dealing with men, sound judgment and a vision of the future, he has been a great asset to the nation, and we may fortunately hope that he will continue for many years more to bless mankind with his invaluable leadership.

Our age is marked by two tendencies, the democratic and the scientific. In Dr. Welch and his work we find expression of the best in both tendencies. He not only represents the spirit of pure science, but constantly sees and seizes opportunities to direct its results into service of human kind.

Medicine until modern times was a species of dramatic play upon emotions rather than a science made useful through technology. It combined centuries of experience in trial and error in reactions from many drugs, with a maximum of skill on the part of the practitioner in a kindly art of making the patient feel as hopeful and comfortable as possible while he was dying of the disease, the origin and treatment of which were as yet undiscovered. Providence was made responsible for his fate, rather than the bacillus which should never have been allowed to infect him.

Modern medical practice, however, is based upon a vast background of scientific research and discovery. In the creation of this science, in the conversion of its principles into technical methods for use in actual practice, in the diffusion of knowledge of these principles and methods and in the application of them upon a national and world-wide scale, Dr. Welch has played the leading American part.

As a research worker in pure science he has made original and valuable discoveries. As a technologist he has devised practical methods of applying pure science. As a teacher he has spread true knowledge and inspiration among thousands and hundreds of thousands. But in organizing and directing research and application of medical knowledge on a wider field of prevention of disease, he is among the preeminent few who deserve the title of statesman.

No valuable change in everyday practice of any of the great arts has ever been made that was not preceded by the accretion of basic truths through ardent and painstaking research. This sequence that precedes effective action in medicine is equally important in every field of progress in the modern world. It is not the method of stirred public emotions, with its drama of headlines; it is rather the quiet, patient, powerful and sure method of nature herself, of which Dr. Welch is the master.

Dr. Welch has happily combined in his character and intellect the love of truth and the patient experimental habit of the pure scientist, with the ingenuity of the inventor and the organizing vision and energy of the promoter of sound enterprise—and combines all these things with a worldly wisdom and gracious charm that have made him a leader among men.

I know that I express the affection of our countrymen and the esteem of his profession in every country when I convey to him their wishes for many years of continued happiness.

SCIENTIFIC NOTES AND NEWS

AT the banquet in Washington on April 8 celebrating the fiftieth anniversary of the American Society of Mechanical Engineers, President Hoover was presented with the first Hoover Gold Medal, founded "to commemorate the civic and humanitarian achievements of Herbert Hoover," and to be awarded hereafter for distinguished public service by engineers. The presentation was made by Dean Dexter S. Kimball, president of the board of award and past president of the society. The ceremony opened the exercises, which were presided over by Professor William F. Durand, past president, as toastmaster. Charles Piez, president, made an address on "The Broadening Responsibilities of the Engineer" and Dr. Robert A. Millikan followed, speaking on "The Bonds between Science and Engineering."

THE Founders' Medals of the society were presented at a luncheon at the Mayflower Hotel. Acting as honorary chairman was Ambrose Swasey, one of the six survivors of the founders of the society and a past president. John R. Freeman, also, past president, presided. Those honored besides Mr. Swasey were: John W. Cloud, of London; John S. Coon, Atlanta, Georgia; Robert Grimshaw and Francis H. Richards, of New York, and E. H. Robbins, of Pittsfield, Massachusetts.

GOLD and silver medals constituting the Rumford Premium of the American Academy of Arts and Sciences were presented on April 9 to Dr. John S. Plaskett, director of the Dominion Astrophysical Observatory, Victoria, B. C., in recognition of his researches on stellar spectroscopy. On the occasion of the award of these medals Dr. Plaskett addressed the academy on "The Gases of Interstellar Space."

DR. WILLIAM ELGIN WICKENDEN was inaugurated as president of the Case School of Applied Science on April 11. Delegates from 48 research and national scientific bodies and from 115 colleges and universities attended. Dr. Dexter S. Kimball, dean of engineering, Cornell University, spoke for engineering, and Dr. Charles G. Abbot, secretary of the Smithsonian Institution, for science. Frank A. Quail, president of the board of trustees, delivered the opening address.

DR. IRVING LANGMUIR, director of the Research Laboratory of the General Electric Company at Schenectady, addressed an audience of German scientific men, in Berlin, including Professor Albert Einstein, on March 11, on "The Chemical and Electrical Properties of Absorbed Films on Tungsten."

DR. FELIX W. PAWLOWSKI, Guggenheim professor of aeronautics in the college of engineering of the University of Michigan, has recently been elected a fellow of the Royal Aeronautical Society of England.

THE William Mackenzie Medal for 1929 for original contributions to ophthalmology has been awarded by the Glasgow Eye Infirmary to Professor Dr. van der Hoeve, of Leyden, Holland.

VICE-ADMIRAL SIR ROBERT DIXON, president of the Institute of Marine Engineers, and Dr. H. J. Weld, organizer of the Weld-Ashmolean Expedition to Kish, have been elected members of the Athenaeum Club, under the provision that empowers the election of persons of distinguished eminence in science.

THE honorary membership of the Academy of Sciences of Finland has been conferred on Sir J. C. Bose for his contributions in advancement of knowledge of life-reactions in plants.

AT a reception held at the Egyptian Legation in London on March 12 the chargé d'affaires, Dr. Hamed Mahmud, presented to Lord Moynihan, of Leeds, president of the Royal College of Surgeons, the Grand Cordon of the Order of the Nile, bestowed on him by King Fuad.

REAR-ADMIRAL ANDREW T. LONG, of the United States Navy, received sixty-one votes in an election for a successor as head of the International Hydrographic Bureau to Rear-Admiral Albert P. Niblick, United States Navy, who died last year. Seventy votes are necessary for election. Captain Mares, of Great Britain, had forty-six votes; Captain Speiss, of Germany, twenty, and Captain Laujauns, of Holland, eight.

DR. JAMES BRYANT CONANT, professor of organic chemistry of Harvard University, has been elected a member of the board of scientific directors of the Rockefeller Institute for Medical Research.

PROFESSOR JOSEPH B. SHAW, head of the department of ceramics in the School of Mineral Industries at the Pennsylvania State College, has been selected by the Bangor Association of Slate Manufacturers as its representative to work with the Bureau of Standards in fixing standards and devising tests to insure uniform grades of roofing slate for government use.

E. M. MERVINE, professor of agricultural engineering at Iowa State College, has resigned in order to enter the service of the U. S. Department of Agriculture. As agricultural engineer he will devote his time to the investigation and development of sugar-beet machinery.

GILBERT L. STOUT, who since 1926 has been field botanist for the Illinois State Natural History Survey with headquarters at the University of Illinois, has taken a position as plant pathologist with the California State Department of Agriculture at Sacramento.

DR. LYMAN F. KEBLER, for many years government specialist in drugs and medicines, dealing with the enforcement of food, drug and mail-order laws, is reported by the *Journal* of the Washington Academy of Sciences to have been made medical director of the Tennessee Products Corporation at Nashville, where his work will include assistance in the utilization of by-products, medicinally and otherwise, as well as health matters connected with the corporation's activities. Dr. Kebler will continue to be medical director of the John McEntee Bowman health interests, identified with the Biltmore chain of hotels, and in addition to his general headquarters in Washington, D. C., will have offices in Nashville and in New York City.

DR. HOWARD B. STOUGH has been promoted to the professorship of zoology and has been made head of the department at the University of Idaho.

DR. CHARLES CHRISTIAN JOHNSON, instructor in pharmacology at the Stanford University School of Medicine, has been appointed professor of pharmacology in the School of Medicine of the University of Utah.

DR. HARVEY J. HOWARD, professor of ophthalmology at Washington University, Saint Louis, announces the following appointments in the department: Dr. George H. Bishop, now associate professor of physiology in the School of Medicine, professor of applied physiology; Dr. Louis A. Julianelle, of the Rockefeller Institute for Medical Research, associate professor of applied bacteriology and immunology; Dr. James A. Hawkins, also of the Rockefeller Institute, associate professor of applied biochemistry; Dr. R. Wendell Harrison, of the University of Chicago, instructor in applied bacteriology and immunology, and Mr. Garvey Bowers, of the University of Kansas, research assistant in applied bacteriology.

Nature reports that in connection with the Physical and Chemical Survey of the National Coal Resources, which is one of the aspects of the fuel research work of the Department of Scientific and Industrial Research, the department has recently appointed a committee to deal with the West Yorkshire Coal Area. Among the members are: Professor J.

W. Cobb, Leeds; Professor J. A. S. Ritson, Leeds; Mr. C. E. N. Bromehead, Geological Survey of Great Britain; Dr. C. H. Lander, director of Fuel Research, and Dr. F. S. Sinnatt, superintendent of the Coal Survey. The object of the survey is to investigate the characteristics of the various coal seams in Great Britain with the view of their utilization to the best advantage. Local laboratories are established in each area for the examination of samples, and, when necessary, large-scale investigations are carried out at the Fuel Research Station (East Greenwich) or elsewhere.

Dr. C. O. Swanson, head of the department of milling industry at the Kansas State Agricultural College at Manhattan, has been granted leave of absence from May 1 to September 30 to enable him to make a study for the U. S. Department of Agriculture of the utilization of American wheat in Europe.

Dr. Thomas R. Garth, professor of educational psychology in the University of Denver, is conducting researches on the color blindness of Indians, starting at Santa Fé, New Mexico.

Walter Granger, paleontologist and second in command of the Central Asiatic Expedition of the American Museum of Natural History, and Albert Thompson, assistant paleontologist, sail from Seattle on April 18 for Peking, where they will join Dr. Roy Chapman Andrews on the fifth and final trip of the expedition into the Gobi Desert.

Dr. Robert A. Millikan gave an address on April 10 in the engineering auditorium, New York City, on "Recent Advances in Our Knowledge of the Universe around Us," under the auspices of the American Institute of the City of New York, the Museums of the Peaceful Arts and the New York Electrical Society.

Dr. Chas. B. Davenport, director, department of genetics of the Carnegie Institution of Washington, at Cold Spring Harbor, L. I., delivered an address on "The Mechanism of Organic Evolution" before the Washington Academy of Sciences on April 16.

Dr. Wilder Dwight Bancroft, professor of chemistry at Cornell University, is to give the dedicatory address on "Modern Science" when the Hall of Science of the University of Southern California, the final wing of which has recently been completed, is formally dedicated on June 6, during the one-week semi-centennial celebration.

Dr. Joseph Erlanger, professor of physiology in the Medical College of Washington University, St. Louis, will deliver the Hitchcock lectures at the University of California, beginning on April 21. The general subject of the lectures is "The Analysis of the Electrical Manifestations of Nerve Action."

The first course of lectures under the Porter Lectureship in Medicine of the University of Kansas School of Medicine was delivered on April 1 and 2 at the Bell Memorial Hospital by Dr. Lewellys F. Barker, emeritus professor of medicine, Johns Hopkins University. The subjects of the lectures were "Diagnosis and Treatment of the Commoner Personality Disorders" and "Psychology and Medicine."

Dr. A. J. Carlson, professor of physiology at the University of Chicago, lectured to the students and faculty of the Vanderbilt University School of Medicine on March 31. His subject was "Organotherapy." The lecture was given under the auspices of the Phi Beta Pi fraternity.

Walter A. RuKeyser, who has recently returned from a five months' trip in Russia, where he served as technical adviser to Uralasbest, the state absestos trust, gave recently a lecture before the department of geology of Princeton University on "The Consulting Engineer in the Union of Socialist Soviet Republics."

Dr. Victor M. Goldschmidt, professor of mineralogy and crystallography at the University of Göttingen, gave in March lectures on chemical geology at the University of London.

The Experiment Station Record calls attention to the Ninth International Horticultural Congress which will meet in London from August 7 to 15 under the auspices of the International Committee for Horticultural Congresses and by invitation of the Royal Horticultural Society. Addresses are scheduled for three days and will be divided into three main groups of propagation, pomology, botanical gardens and general subjects. The remainder of the time will be largely devoted to excursions to private and commercial gardens, nurseries and similar establishments, the gardens of the Royal Horticultural Society and the Royal Botanic Gardens at Kew, the Rothamsted Experimental Station and the research stations at East Malling, Cheshunt and Long Ashton, and the John Innes Horticultural Institution. There will also be a special horticultural exhibition on August 14 and 15.

An international league for combating trachoma was founded at the thirteenth International Ophthalmological Congress. The president of the league, Professor Emile de Grósz, and the secretary, Dr. F. Wibaut, were entrusted with the formation of a committee composed of delegates from the various national ophthalmological societies. Up to the end of February forty-nine delegates had been nominated from twenty-six countries. The next meeting of the league will be held on July 26 in Geneva, and the program will be issued at the close of May.

AN institute of natural sciences will be held at Bowdoin College early in 1931. This will be the fifth institute in the series begun in 1923, the first four having covered the fields of modern history, literature, the fine arts and the social sciences.

THE Twenty-fourth Annual Convention of the Illuminating Engineering Society is to be held in Richmond, Virginia, from October 7 to 10. Present plans contemplate sessions to be devoted to lighting practice, natural lighting, lighting service, ultra-violet radiation, lighting education, light in architecture and decoration, as well as the usual business sessions on the opening day. The committee on lighting service is also planning to hold a pre-convention meeting on the day immediately preceding the opening of the convention, which will be devoted entirely to subjects of interest to central-station lighting service engineers. This will be held on October 6.

SIGMA PI SIGMA, honorary physics fraternity, has granted petitions for charters at the University of Washington, Park College and William Jewell College. Chapters at these institutions will be installed about the middle of May in connection with the installation of several other chapters at institutions where petitions are now under consideration.

AN Associated Press Dispatch reports that the Massachusetts General Hospital, the Boston Museum of Fine Arts, the Massachusetts College of Pharmacy and several other institutions will share to the extent of several millions of dollars in the estate of the late Mrs. Harriet J. Bradbury. The estate is valued at between $12,000,000 and $15,000,000.

MORE than a quarter of a million dollars has been subscribed to the centennial memorial building fund of the Medical Department of the University of Georgia for the erection of a building to commemorate the one-hundredth anniversary of the founding of the medical school by Dr. Milton Antony in 1823. The sum of $40,000 still remains to be subscribed.

MR. JOHN D. ROCKEFELLER, JR., has offered to contribute $250,000 to an endowment fund of $2,000,000 which is being raised for the International Y. M. C. A. College at Springfield, on condition that $1,750,000 be received in cash from other sources before July 1, 1935.

OHIO WESLEYAN UNIVERSITY has received a bequest of $50,000 by the will of Frank E. Stuyvesant, of Cleveland, Ohio.

THE nineteenth Annual Report of the Brooklyn Botanic Garden contains a résumé of research that has been in progress during 1929, including studies of the diseases of cereal grains, beardless iris project, forest pathology, systematic botany and genetics; also a summary of the educational activities. Over 1,127,000 visitors were recorded at entrance turnstiles, and study material including living plants and petri dishes with sterile agar were supplied to 6,457 teachers for the instruction of 282,000 pupils. Over 795,000 packets of seeds were supplied to school children for planting in school and home gardens and 38 exhibits were installed in the public schools of Brooklyn and other boroughs. Numerous gifts are also recorded.

DISCUSSION

COSMICAL MATTER AND STELLAR EVOLUTION

IN his address before the British Association for the Advancement of Science at the recent meeting in Cape Town, as given in SCIENCE of July 26 last, Lord Rayleigh touches on what would be called in Spanish countries a "palpitating question" in astronomical problems of to-day.

The importance of the underlying cause of the spectral conditions which he discusses can not be overestimated. But there are some points in connection with the nebulae especially in which it seems to me a diversity of opinion is permissible.

Interest in the relation of nebulosity to early-type activity, although not in the same sense as Lord Rayleigh appears to favor, was stated in an article on the cause of stellar spectral differences.[1]

[1] *Ap. Jour.*, 47: p. 305, 314, 1918.

It has been a profound mystery to me why so obvious a source of energy and one so efficacious as cosmical matter has been ignored—not simply unrecognized, for it has been found everywhere, but just ignored. Clouds of it, great and small, abound in the Milky Way; the great nebulae such as Orion, Trifid, Eta Argus and M8 show it; all the spiral nebulae large enough to show detail reveal it; the meteors in our atmosphere, the corona and zodiacal light about our sun are other examples. We also find many variable stars and novae enveloped in clouds which are best explained as such. Comets are doubtless nothing but clouds of such matter, and the asteroids are believed to have a similar constitution.

The Pleiades are enveloped in a great cloud of such matter, and a great many early-type stars have clouds either attached or near.

From the evidence which exists it would be more justifiable to assume that the effects of cosmical matter in some form are universal than that they are negligible.

At this point I would emphasize the criticisms which have been made of the too ready acceptance of anything which is largely mathematical formulas. No one will deprecate the value of mathematics as a tool, but there is entirely too great a tendency to ignore the material upon which the tool is used. Instances are familiar to all; among them may be cited the work on the internal constitution and spectral conditions of the stars and of the distances of the Cepheid variables, globular clusters and spiral nebulae. To these may be added in a lesser degree the parallaxes of the more distant stars determined directly.

Recent happenings point to a drastic revision of distances of the Cepheids, and in consequence, of all the objects based upon them, hence this case need not be pursued. There is still the case of the direct determinations of the parallax which is more obscure and not generally understood. In passing it may be said that the error in question appears to arise from the effect of spectral type on magnitude and consequently distance which has been ignored because unnoticed.

Regarding the first case, my criticism applies particularly to the work which has been done upon the internal conditions of the stars as an explanation of spectral conditions in general.

The spectral condition of a star is essentially a surface condition. It is undoubtedly affected by internal conditions but to what extent is entirely unknown, and in my opinion to place all the responsibility on conditions as hypothetical as internal ones is highly speculative, to say the least. It is even possible to reconstruct Herschel's frozen-cored sun with just as much reason and scientific basis as some of the theories proposed in the past half century. We have in the large meteorites evidence of possible frozen cores and in the existence and effects of cosmical matter a means of producing almost any surface condition as evidenced by the novae.

I am not arguing for frozen-cored suns, merely pointing out the weakness of any theory based wholly on conditions so purely speculative as internal ones.

If there were no other course it might be justifiable.

But there is direct and weighty evidence that much of the spectral condition of the stars, at least the early types, is due to external causes alone. Internal conditions furnish no explanation whatever of the preferences of all these early-type objects including the gaseous nebulae for the Milky Way.

I maintain the thesis that only some sort of external condition or conditions are adequate and logical to cause such preferences and demand the production of evidence to the contrary or that internal conditions alone will account for these preferences.

My object in touching so strongly on the question of the cause of the spectral condition of the early-type objects is to prepare the way to oppose what I understand to be the general attitude toward that problem. Lord Rayleigh focuses the matter when he emphasizes the intimate relation of the central stars of the planetaries to the surrounding gaseous nebulosity. About that fact there can be no reasonable difference of opinion. It is with the underlying assumption that the central star is the exciting cause of the gaseous nebulosity that my criticism lies, but even more with the assumption that the gaseous nebulosity is the starting-point of stellar evolution.

Lord Rayleigh is more physicist than astronomer and therefore is presumably more interested in the purely physical side. He does not definitely so state but I understand his statement that ". . . the source of excitation in the bright line nebulae no longer appears inexplicable" and that "the cases of some of the central nuclei of the planetary nebulae are specially satisfying from the definite relation of the star to the nebula and the adequate character of the star itself" to mean that the central star is considered to be the exciting cause of the nebulosity. Such is almost certainly *not* the case. The evidence favors the hypothesis that *both star and nebulosity have been excited by a common cause.*

In the novae we have what is the only analogous course known and one which appears to satisfy the conditions of formation of these planetary nebulae also. Indeed the only essential difference appears to be in the rapidity in which the novae pass through the different stages. In a few weeks or months the nova passes successively through the spectral conditions A, B, O and gaseous nebulosity. And to complete the analogy some of the brighter novae have presented expanding disks in the nebulous stage.

Not only have we that evidence, but unpublished investigations indicate that the planetary nebulae may be in different stages of expansion and contraction. This is shown both by their radial velocities and their appearances.

If this were not enough we have the further supporting condition that in the O-type stars those showing emission (Wolf-Rayet stars) appear to be expanding whereas those showing only absorption have predominantly positive radial velocities indicating contraction, atmospheric probably.

If such are the conditions in the planetary nebulae and O-type stars strength is lent to the hypothesis

that some of the excess of positive velocity in the B-type stars may be due also to contraction. Upon these hypotheses all the early-type activity can be accounted for, even the outstanding and discordant large radial velocities of the planetary nebulae which have been a stumbling-block to the proper location of these bodies in any otherwise logical course of change.

The course followed by these early-type objects, as indicated by the above conditions, may be summarized as follows:

Stellar (or perhaps other) bodies in the galactic regions where cosmical matter is sufficiently plentiful encounter such matter in the form of clouds of varying conditions as to size and motion.

The effects of such matter begin to be noticeable in the A type, and probably also as short-period variables in the F, G and K types which show a marked preference also for the galactic regions. These preferences become progressively stronger through the B-type stars until we find those of O type confined to a narrow belt along the plane of the galaxy.

These encounters will in general reduce the motions of the original stars due to the combination of different motions of the star and cloud and perhaps also to a general retardation by widely distributed matter which appears to have little or no system motion in many cases. This would account in part for the generally small motions of the early-type objects.

Strong evidence has recently been encountered, however, that the great brightness of the early B-type stars is due to a brightening up of stars whose proper motions were originally small, due probably largely to distance.

The sequences of change in both spectral type and temperature accord with increasing amounts of cosmical matter encountered which first produces an apparent excess of positive radial motion or contraction in the B-type spectrum which increases in the late O-type and then changes to negative or expansion when the emission appears in the early subdivisions.

The planetary and large extended gaseous nebulae are the results of encounters with single stars and groups respectively in which the climax appears to have been produced, resulting in gaseous nebulosity and probably radiations of shorter waves which are not observable with our present means.

Incidentally it may be pointed out that encounters of solid bodies with clouds of cosmical matter furnish an explanation of the large meteorites, these being the pieces of small solid bodies disrupted by the sudden heating of such encounters much as the meteorites themselves are disrupted in passing through the earth's atmosphere.

If such a course is the correct interpretation of the phenomena observed in these early-type objects the nebulosity is not being maintained by "excitation" of a central star or other source but is the *result* of the primitive originating encounter and is simply a stage more or less transitory in stellar evolution, broadly considered.

Indeed the phenomena of the novae and especially the planetary nebulae raise the question whether the secondary bodies of our solar system may not be the later stages of the outer portions of a planetary nebula. The physical appearance of these bodies which show predominating positive velocities is such as to suggest condensation.

As these objects and the novae all show strong preferences for the Milky Way the question naturally presents itself as to what causes the activity in them, activity which appears to increase from A- to B- and O-type and to culminate in gaseous nebulosity in the planetary and large irregular nebulae as well as the novae.

Here is where cosmical matter intrudes itself as outlined above. Together with gravitation it furnishes a natural and satisfactory explanation for this early-type activity, and so far it is the only one. I have hunted diligently for objections but thus far have found none. One object in raising the point is to invite discussion and to uncover contradictory evidence if it exists.

As yet this question is not one for mathematical formulas except incidentally but for broad common sense.

C. D. PERRINE

OBSERVATORIO NACIONAL
CÓRDOBA, ARGENTINA,
SEPTEMBER, 1929

PSITTACOSIS EPIDEMICS AND PLEOMORPHIC PROTOPLASM

THE note in the issue of March 7 on the etiology of parrot disease and the possibility of a filterable virus suggests that laboratory workers in New York State, and perhaps the scientific world generally, may be unfamiliar with the work done during the epidemic of 1917 in Pennsylvania. At that time, Dr. A. T. McClintock, a young Wilkes-Barre pathologist and diagnostician, trained in Vienna and Berlin, carried on extensive researches with cultures obtained from three affected parrots and from the bloods, sputa and feces of eleven patients. He used mice and rabbits for inoculation, checking his results through the experimental induction of similar disease pictures by means of cultures derived from the feces of normal parrots.

His tentative conclusions are suggestive, though in a dozen years laboratory technique has doubtless undergone manifold refinements. While identifying the epidemic as psittacosis, he failed to associate with it Nocard's bacillus (a stout motile Gram nega-

tive rod) as the causative factor. Nocard's findings (1892), he believed, represented a fixation of species, whereas the local epidemic (less virulent in form, with a mortality of only 5 per cent.) was apparently derived from a "generalized" bacterial protoplasm, often amorphous, residing in the intestines of the healthy parrot of this species in a harmless saprophytic guise. This more primitive form conceivably retained a plasticity which under the stimulus of abnormal conditions enabled it to undergo metamorphosis, assuming a number of different forms, rod-like or coccal, and displaying an affinity for a wide range of living tissues. The chilling of healthy birds and the resultant changes in intestinal exudates were surmised to serve, in natural surroundings, the same rôle as the bouillon extract which, in the laboratory, sufficed to provoke mutation and the development of pathogenic traits in the intestinal flora obtained from healthy birds.

It was found possible to induce the disease with material which had passed a filter, but in less virulent form, with slower course. In McClintock's opinion, the larger, centrifugible units were more effective. As in previous epidemics, there was an incubation period of from five to ten days, and there was lack of evidence of the transfer of infection from one human being to another. Three forms, influenzal, pneumonic and typhoidal, all accompanied by severe headache, were distinguishable in human patients, though the typical tests for pneumonia and typhoid were negative and agglutination variable. Post-mortems, however, revealed the hemorrhagic conditions characterizing the disease picture throughout the tissues, although most frequent in the lungs or intestines of the affected bird or animal. In spite of the mounting evidence of contact between sick birds and patients, the state authorities, so far as I recall, refused to identify the disease as psittacosis.

McClintock's preliminary findings were reported before the Luzerne County Medical Society on May 17, 1917. The detailed account of his researches, including his hypothesis relating the Wilkes-Barre epidemic to a more primitive, less differentiated form than that represented by Nocard's bacillus, lay in manuscript until 1926, owing to conditions peculiar to the war period. McClintock saw a possible connection between the etiology of psittacosis and that of trench fever, and rushed his monograph to conclusion outside the long hours absorbed by his private practice and his duties as pathologist at the city hospital, working over his results from 8 to 12 at night, writing from 5 to 8 A. M. In September, 1918, while hunting a publisher and making final arrangements for army service, he contracted the influenza then epidemic in a severe and all but fatal form, never regaining his health. Publication under the existing war conditions proved impracticable, and so far as I know he never touched his manuscript again. It was printed posthumously in 1926 as "Pleomorphism in Bacterial Protoplasm: A Study in Psittacosis," in a form which the author had hoped would render it useful as an introduction to pathogenic bacteriology —a field in which, his researches convinced him, a less dogmatic approach than the conventional one was desirable.

McClintock's view that psittacosis is not a simple disease entity, that the causative factors in different epidemics may be different and may, in certain instances at least, be derivable from a minute, unfixated protoplasmic form, harmless under normal conditions of the host, certainly merits wider dissemination among laboratory workers.

ELSIE MURRAY

CORNELL UNIVERSITY

ARTIFICIAL BACILLI

IN September, 1928,[1] I communicated to this journal a preliminary report on the discovery of living micro-organisms in certain Precambrian rocks. These investigations have been continued and have involved painstaking and laborious checking of the technique employed. While the indications are still as given in the earlier paper, a final statement with respect to them must await the completion of a little further work. A final report should be ready next summer. Meanwhile, conclusive evidence has been obtained to prove the existence of living micro-organisms in anthracite coal derived from mines in Wales and in Pennsylvania. The interpretation of these results does not accord with those of Schroeder, Galle, Potter and Lieske, who also worked with anthracite coal. I hope soon to furnish a report also on these investigations.

Incidental to the study of the bacterial flora of rocks, however, the attempt to work with strictly sterile media has led to a striking discovery which I present in this communication. When agar in the shredded or powdered form is mixed with tap water, sea water or other salt solutions in the cold, a microscopic examination shows only the irregular shapes and sizes of colloidal particles. When, however, it is heated in such solutions to a temperature of 45° C. or more, a microscopic examination of stained and unstained preparations thereof reveals a large number of perfectly shaped rods varying in length and thickness. These forms are practically always rod-shaped with rounded ends and most strikingly resemble bacilli. They even show diplo-bacillus forms

[1] SCIENCE, 68: 272–3, September 21, 1928.

as if the rods were in process of division. They take the methylene blue and gentian violet stains readily and frequently show polar, more deeply stained spherules and other structures in the interior. These rods are not bacteria since even sterilization of the agar for fourteen hours or more in the autoclave at pressures varying from eighteen to twenty-two pounds fails to destroy them, and since besides the original agar suspension does not contain them but a few minutes' heating produces them.

A discussion of this discovery with Professor J. W. McBain, of Stanford University, convinces me that I have discovered a colloidal phenomenon which is the result of the assumption of one form of structure among the compounds of the agar which takes expression in the type of aggregates just described. This form is evidently fairly insoluble and fairly stable. An account of the studies carried out respecting the properties of these artificial bacilli will be published later.

As regards the foregoing statements it may be said that we are dealing with facts which can be easily confirmed by any one. It is fascinating, however, and irresistible to speculate as to whether or not these artificial bacilli may, under the proper environmental conditions, take on the properties of living cells. While of course this seems like a wild notion, I am investigating this possibility.

To Mrs. Dorothy Doyle Thomas, who is assisting me with the laboratory investigations, I wish here to express my thanks.

CHAS. B. LIPMAN
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ACTION OF BACTERIA AND ENZYMES ON CARBOHYDRATES AND THEIR BEARING ON PLANT SYNTHESIS

THE question of the nature of plant synthesis is an important one not only for the plant physiologist but also for the scientist concerned with the structure and industrial application of products of plant metabolism. This is particularly true with regard to the utilization of derivatives such as sugars, starch, inulin, cellulose, etc.

One interesting mode of attack appears to lie in an investigation of the action of bacteria and their corresponding enzymes on carbohydrates and polysaccharides, a method which has been followed with some success by two of my coworkers, Messrs. H. L. A. Tarr and R. S. Tipson. It has long been known that *Bacillus mesentericus* converts cane sugar into "gum levan," and it is now found that the same change is apparently brought about by the enzyme isolated from the bacteria. "Gum levan" has been definitely identified by methylation, acetylation and hydrolysis experiments as a polymerized form of an anhydro fructose derived from "active" or "gamma" fructose. It is closely related to inulin, which is the fructose-anhydride-polysaccharide found in the dahlia and artichoke.

Complete methylation of "levanose" (gum levan), followed by hydrolysis, yields crystalline trimethyl γ fructose, which, so far as known, is the first crystalline active or gamma sugar to be isolated.

The action of *Bacillus mesentericus* and its enzyme is specific. They do not bring about any changes with carbohydrates and sugars in which the active form of fructose is absent. Raffinose apparently yields the same product as cane sugar. The action on gentianose and melezitose is to be investigated.

Bacillus xylinum (Aceto bacter xylinum) acts upon glucose, mannose, galactose, maltose, sucrose, fructose, "levanose," etc., with "pellicle" formation and change of the carbohydrate into a polysaccharide. It appears to convert glucose directly into cellulose. Of the sugars already examined the only one on which it exerts no action is lactose.

The action of both bacteria and enzymes on a variety of carbohydrates is being actively investigated and the preliminary results are to be published in the immediate future in the *Canadian Journal of Research*.

Of considerable interest is the fact that *Bacillus xylinum* is apparently able to carry the polymerization of "gum levan" to a further, more complex, stage.

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SPECIAL CORRESPONDENCE

THE MONTANA TICK PARASITE EXPEDITION TO AFRICA

IT is now possible to summarize the 1928 African tick parasite expedition of the Montana State Board of Entomology. The purpose of the venture was to get as much information as possible on parasites that destroy ticks and particularly to discover new parasites which might be brought to America to be used in the possible control of the Rocky Mountain spotted fever tick, *Dermacentor andersoni* Stiles. The procedure was to collect as many ticks as possible from all kinds of domestic and wild animals, hold them under observation alive and determine if parasites were present. Effort was made to extend the collecting over as wide areas as possible and, at the same time,

to give particular attention to those areas where ticks were known to be not very abundant because, where no other cause was evident, parasites might account for the small number of ticks. With laboratory headquarters at the Veterinary Research Laboratory at Onderstepoort, Transvaal, collecting trips were made to various parts of the Union of South Africa and ticks were obtained from all the provinces. Some three weeks' collecting was done also in the Province and Protectorate of Kenya, in the region near Lake Naivasha.

Well over fifteen hundred animals were examined, including many large and small wild animals, and approximately eight hundred tubes of ticks, including some thirty-four species, were collected. An *Ixodiphagus,* closely related to and possibly identical with *I. caucurtei* Du B. of France, was discovered preying on *Hyalomma aegyptium* L. in the Transvaal. This parasite was recovered several times and for the first time it was possible to make a study of an *Ixodiphagus* in a colony of the insects under natural conditions.

The recovery of *Ixodiphagus* and the studies made on the species were considered to be of enough interest to repay for the venture, but the trip resulted in other discoveries which may prove to be of the greatest importance. Six days after the writer sailed from Durban *en route* to Mombasa, Dr. G. A. H. Bedford, entomologist in the veterinary laboratory staff, discovered a chalcid which attacks adult ticks. These insects are not yet named and almost nothing is known about them. Some weeks later, on the occasion of a visit to South Africa, Dr. Robinson, Cooper's parasitologist, when told of the parasite work now being done in South Africa, stated that some years ago he had received a box of adult *Amblyomma hebraeum* Koch from Cape Province and on arrival in England the box was found to contain adult chalcids which had emerged in transit. He further stated that the insects were evidently of a species different from the one discovered by Dr. Bedford, which Dr. Robinson had an opportunity to examine. This chalcid likewise has not been named or studied. It is therefore reasonably certain that there exist in South Africa two new chalcid parasites of adult ticks which the writer did not have opportunity to study.

Through Mr. C. B. Philip, of the West African Yellow Fever Commission, Rockefeller Foundation, Lagos, Nigeria, Africa, we have learned also of the recent discovery of a colony of an unidentified tick parasite in Nigeria.

The parasite expedition to Africa has indicated that the continent is a promising field for further search. A thorough study of the parasites in Africa will be a necessary preliminary to their importation into America.

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QUOTATIONS

DR. WELCH'S "APOTHEOSIS"

What the Grecians called "apotheosis," said Bacon, was "the supreme honor which man could attribute unto man." In that definition of the word, the supreme attribution of honor to Dr. William H. Welch to-day becomes his apotheosis. The nation pauses to give him its highest praise while he still lives. Another great physician, Sir Thomas Browne, in his "Religio Medici," said that he cared for not so much as the bare memory of his name to be found anywhere after his death save in "the universal register of God." But fame pays little attention to the prayers of those whom she delights to honor. It is he among teachers who has overcome that "last infirmity"—the desire to be remembered—that is most likely to be chosen. Dr. Welch has gone his way doing what his kindly genius has suggested without other prompting than the appeal of the thing that needed to be discovered or done for humanity.

He has been called "a first citizen of the scientific world." He has three major achievements to give substance to the distinction that will outlive the personality which has made him both loved and admired. He organized the faculty of the Johns Hopkins Medical School nearly fifty years ago and the Johns Hopkins School of Hygiene and Public Health fifteen years ago. Then, with an undaunted spirit which discredits the general theory of his associate, Dr. Osler, he began when he was almost twice forty years old to develop the history of medicine as a new discipline in the training of physicians, with a library as his laboratory. The fourscore years have not abated his "eternizing passion" in the warfare against the enemies of man's bodily health and social welfare.

The substance of his achievement has been illumined by an old-time spirit of scholarship and graced by an art which is the "happy science of the soul." Like the one who is mentioned by Theocritus in his tribute to Asclepius, the father of medicine, Dr. Welch "put all his art into the work." That is his special distinction. He is both scientist and artist in the highest meanings of both words.

Hippocrates found life short and the art of healing long. Fortunately the life of this great modern physician who took early the Hippocratean oath has

been lengthened to make more serviceable to his fellow-beings the art of healing, in both its preventive and its curative ministries. There is nothing left to wish him but still more years in the practice of this art before he "goes to the stars."—*The New York Times.*

SCIENTIFIC APPARATUS AND LABORATORY METHODS

HEAT TRANSMISSION THROUGH BLANKETS

SOME three years ago I was approached by a large manufacturer of blankets with the request to devise a method for measuring the "heat-retaining property" of blankets. These tests were to be not only for the sake of determining the coefficient of heat conduction of various kinds of blankets, but especially for the purpose of obtaining some data on the basis of which blankets could be improved.

There were, of course, the usual well-known methods available, but it seemed desirable to test larger samples than were generally used and also under conditions which more nearly resembled actual usage. Since what we may call the "normal conditions" for a blanket in use are based on body temperature and room temperature, I devised an apparatus in which the heated body was kept at 37° C. (98.6° F.) and surrounded by air at the temperature of a cool room, 13° C. (55.4° F.). The apparatus finally took the form shown in Fig. 1.

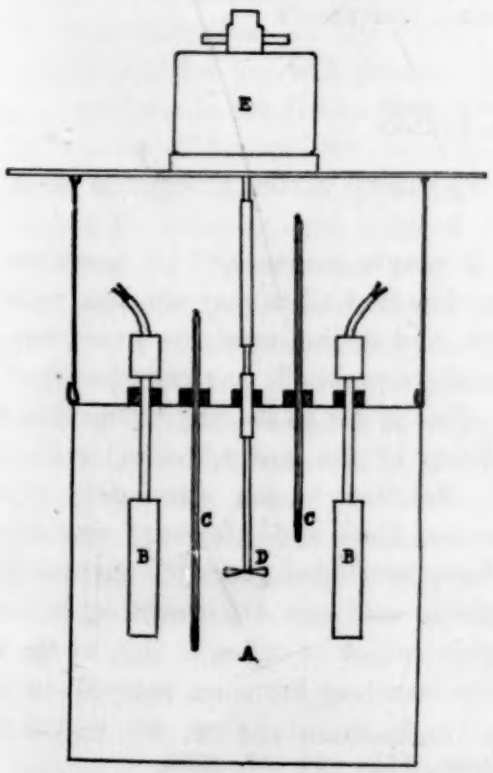

FIG. 1

A is a copper vessel 12 x 12 x 3½ inches, rounded at the sides and bottom and closed with a flat plate at the top. In the plate are five apertures from which are suspended by rubber or cork stoppers two immersion heaters B, two thermometers C and an agitator D, run by a motor E. The thermometers are placed so that one has its bulb a few inches below the center of the body and the other as much above. The vessel is filled with water, and when the stirring device is in motion the difference between the two thermometer readings is about 0.1° C. The body is suspended from the upper shelf of the food compartment of an electric refrigerator and the stirring motor is placed on this shelf and connected to the propeller shaft by rubber tubing. The temperature of the air in the food chamber is controlled by a Tagliabue Snapon controller, the bulb of which is not in the brine but in the food chamber, behind the body and near the back wall of the refrigerator. This control gives a maximum variation of about 1½° C. from mean.

The energy is supplied to the heaters by a storage battery and measured by a precision voltmeter and ammeter. The temperature of the body is measured by the two thermometers C, and the temperature of the box by two thermometers not shown in the figure, one placed in front of the body near the door and the other near the right-hand wall of the refrigerator. A cardboard screen placed directly inside the door of the refrigerator and low enough to enable the reading of the thermometers prevents the cold air from rushing out when the door is opened for observations.

The procedure in making tests is as follows. The blanket to be tested is cut in the form of a rectangle 17 x 32 inches and pinned into the shape of a bag which fits over the body snugly but without strain. It is drawn on from below and pinned together at the top, allowing B, C and D to project through. The current through the heaters is now adjusted until the average temperature of the body is 37° C. This of course takes a considerable length of time. The temperature of the box is constantly changing with the turning on and off of the compressor, and inasmuch as an increase above 13° decreases the flow of heat through the blanket and a decrease below 13° increases the flow of heat, there is an accompanying variation in the temperature of the body even though the power supplied remains constant. The rate of variation is of course the same as that of the refrigerator but there is a slight lag. The amplitude of variation of the body temperature depends upon the insulating quality of the blanket used and becomes unnoticeable in case of the "warmest" ones. The rate of change of the refrigerator temperature depends upon the quality of the blanket used and the room

temperature and is greatest for a poor blanket and a high room temperature, as the rate of flow of heat into the refrigerator is then the greatest and the compressor has to work most often.

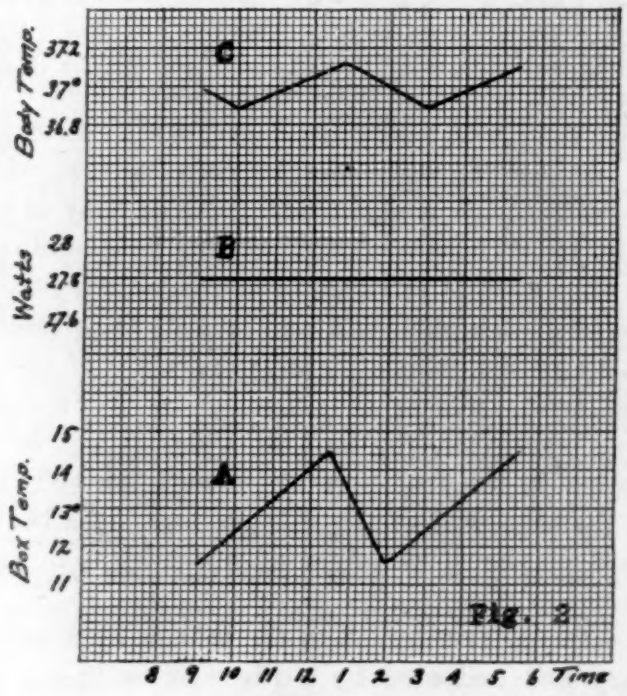

FIG. 2

Fig. 2 shows plots of readings obtained in the test of a good cotton blanket. Curve A shows the variation of the box temperature with time; curve B the power supplied to the body, and curve C the resulting temperatures of the body. The power in watts supplied to the body when its average temperature is 37° while the average temperature of the box is 13° is a measure of the heat-insulating property of the blanket under test. It may be mentioned here that the power supplied to the stirring device is insignificantly small.

Inasmuch as the number of watts which have to be supplied to the body is least for the best blanket it seemed desirable to obtain a measure which was numerically greater for the better insulator. This was done by determining the watts needed when the body was covered with only a cotton sheet in place of a blanket and using as the measure the difference between this value and that for a given blanket. This difference, of course, is greatest for the best blanket.

Knowing the area of the covering and the power supplied, it is possible to compute the energy in B. T. U. which passes through ten square feet of any blanket in eight hours. This I have adopted as my unit in blanket testing. An interesting result obtained was that a single thickness of heavily napped cotton blanket gave 2,730 of these units, which corresponds to the heat value of about two thirds of a pound of lean beef.

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SPECIAL ARTICLES

THE EFFECT OF COLLOIDAL SILICA ON THE ABSORPTION OF PHOSPHORIC ACID BY PLANTS

REPLYING to a criticism of Fisher[1] concerning the interpretation of the effect of sodium silicate in increasing the assimilation of phosphoric acid by barley in the Rothamsted field experiments, Hall[2] suggests that an explanation of the phenomenon may be sought in the colloidal behavior of the sodium silicate in accordance with the theory advanced by Comber.[3] The latter maintains that the soil colloids play an important rôle by being directly absorbed by plants through the formation of a one phase system between the colloidal coating of the plant root hairs and the colloidal coating of the soil particles. This proposed modification[3] of present views by Comber,[3] however, has been critically discussed by the writer,[4] who has shown that the weight of existing evidence does not support the theory of the absorption of colloids by plants.

There is ample evidence,[5,6,7,8] moreover, to disprove the view that silica may act as a substitute for phosphoric acid in the metabolic processes—it is not "phosphorsäuresparend"; nor can the view[9] that the observed effect is due to the improvement in the physical condition of the soil withstand critical investigation.[10] Relative to the alternative explanations presented by Hall and Morison,[7] certain authorities[1,6,8] have concluded from the increased quantity of phosphoric acid per dry weight of the crop that the beneficial effect of silica is due to the increased availability resulting from an increase in the quan-

[1] R. A. Fisher, *Jour. Agr. Sci.*, 19: 132–139, 1929.
[2] A. D. Hall, *Jour. Agr. Sci.*, 19: 586–588, 1929.
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[5] Wl. S. Butkewitsch and W. W. Butkewitsch, *Biochem. Ztschr.*, 161: 468–487, 1925.
[6] P. L. Gile and J. G. Smith, *Jour. Agr. Res.*, 31: 247–260, 1925.
[7] A. D. Hall and C. G. T. Morison, *Proc. Roy. Soc.*, B–77: 455–477, 1906.
[8] O. Lemmermann, H. Wiessmann and K. Sammet, *Ztschr. Pflanzenernähr. u. Düngung*, 4A: 265–315, 1925.
[9] Fr. Duchon, *Ztschr. Pflanzenernähr. u. Düngung*, 4A: 316–325, 1925.
[10] O. Lemmermann, *Ztschr. Pflanzenernähr. u. Düngung*, 4A: 326–330, 1925.

tity of phosphoric acid in the soil solution. Gile and Smith[6] and also Lemmermann[8] concluded that this action is a solvent one on the soil phosphates. The former[6] substantiate their conclusions from experiments (albeit *in vitro*) which showed a greater solubility of rock phosphate in the presence of silica gel, whereas the latter[8] recognizes that the explanation just advanced is incomplete. The fact, however, that plants can thrive in extremely dilute solutions of phosphate ion if the supply is maintained[11,12] even as low as 0.25 p.p.m.[13] proves that the solvent effect of silica on soil phosphates, as suggested by these investigators, is a negligible factor compared with the other more powerful solvent forces present.

The seat of action ultimately must be in the plant itself,[7] for the absorption of ions by the plant is conditioned by the equilibrium conditions prevailing in the interface of the system composed of the ions in the plasma membrane of the root hairs and the ions of the soil solution. Now, in a system containing a non-diffusible ion—$SiO_3^=$ in the case under discussion—a marked effect is exerted on the distribution of diffusible ions on either side of the cell membrane. A non-diffusible electro-negative ion, such as a colloid micelle,[4] will produce a greater concentration of diffusible electro-negative ions and a lower concentration of electro-positive ions on its own side of the membrane than on the other. A non-diffusible electro-positive ion will produce the opposite effect. According to the Gibbs-Donnan distribution law[14,15] at equilibrium the product of the concentrations of each pair of oppositely charged diffusible ions is the same on both sides of the membrane. Hence, in the system under consideration if x and y represent the molar concentrations of the diffusible H and PO_4 ions, respectively, on each side of the interface considered, and z the concentration of the non-diffusible SiO_3 ions, then, according to the Donnan principle, displacement of the diffusible ions takes place in such a way that at equilibrium $x = y(y+z)$. It follows that the greater the concentration of non-diffusible anions ($SiO_3^=$) present, the greater must be the absorption of diffusible anions ($PO_4^{\equiv}$) into the cell. The equation also shows that x and y are equal only when $z = 0$. Practically, there is a limit to the amount of silica that might be added, because of the coating of the root hairs and other factors.[5] Obviously, the Donnan effect will be restricted by the presence of diffusible $xSiO_2 \cdot yH_2O$ ions, some of which will be present in the solution.[4]

The experiments of Butkewitsch and Butkewitsch[5] with collodion membranes and also with maize plants grown in Pfeiffer's nutrient solution with and without phosphoric acid to which different amounts of silicic acid were added afford the first experimental evidence in support of the interpretation just submitted.

It is realized that the Gibbs-Donnan distribution law may not suffice to explain all the facts connected with the absorption of ions from the soil solution by the plasma membrane of the root hairs of plants, for the Donnan principle applies to free ions only. From Wright's investigations[16] on the secretion of the high amounts of calcium in milk from the relatively low concentrations of this element in the blood plasma, it is apparent that the degree of dissociation of the protein salts must be taken into consideration also, since these ions are present in the cell in addition to those which entered to satisfy the product equation. The plant cell is a polyphase system; from this starting-point Briggs and Petrie[17] have deduced that the apparent internal ionic product resulting from the collective effect of all the phases within the tissue in this polyphase system must have a higher value than that of the external medium. It must be kept in mind, however, that deductions from experiments[17,18,19] in isolated tissues or cells of plants, although supplying valuable information, may not necessarily conform to the behavior of the plant as a whole. Herein, from the plant physiology standpoint, lies the value of the type of experiments carried out by Butkewitsch and Butkewitsch.[5]

It remains only to be pointed out that in the Rothamsted experiments sodium silicate, a salt showing a strong tendency to hydrolyze, was used, whereas in the other experiments cited in this paper the silica was added in the form of silicic acid gel. The effect, therefore, of hydrogen-ion concentration on the mobility of ionic pairs must also be considered.[20,21]

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[11] D. R. Hoagland and J. C. Martin, *Soil Sci.*, 16: 367–388, 1923.
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[13] J. F. Breazeale and P. S. Burgess, *Arizona Agr. Exp. Sta. Tech Bul.*, 10: 209–237, 1926.
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[15] F. G. Donnan and A. B. Harris, *Jour. Chem. Soc. (Lond.)*, 99: 1554–1557, 1911.
[16] Norman Charles Wright, *Biochem. Jour.*, 23: 352–357, 1929.
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SEGREGATION (?) IN PHOMA TERRESTRIS

WHILE engaged in a study of the pink-root disease of *Allium cepa* the writer isolated the causal organism *Phoma terrestris*[1] from infected onion roots obtained from the following states: Arkansas, California, Colorado, Louisiana, Massachusetts, New York, Oregon and Texas. Though all the isolated fungi apparently are of the genus *Phoma* and all are able to cause the pink-root disease, they differ markedly in their morphological cultural characters, such as in abundance, shape and size of pycnidia, number and length of ostioles, color of mycelium and substratum, rate of growth, etc. The differences, both macro and microscopic are so obvious and of such magnitude that, were it not for the fact that all these organisms are able to cause the same specific disease, one would be justified (according to precedents set in the taxonomic treatment of other genera in fungi imperfecti) in naming three new species and several new varieties.

In considering causes for such striking variations one might suppose that either an undiscovered perithecial stage exists or that mutations (saltations) are of unusually frequent occurrence. During the past five years extensive culturing on a large variety of media has failed to show any sector formation, and during that period of time no perfect spore-form has been observed either in nature or in culture. Hence other explanations must be sought.

A more intimate study of the California organism revealed the fact that if constant spore-mass transfers were made through several generations pycnidia were produced earlier and in much greater abundance than by mycelial transfers. This phenomenon, which has also been observed in other genera of the imperfect fungi, indicates that the genetic constitutions of spores and hyphae are dissimilar and that therefore single-spore cultures might be expected to differ in some degree from the parent culture. This was found to be the case. Though several morphological characters showed variations during this investigation, only color of the culture as a whole will be considered here. Of fifty single-spore cultures from the California organism forty-two were pink like the parent and the remaining eight were dark, almost black. Several generations from single spores proved this dark variant to be homogenic for color. Subsequent generations of the pink form gave both pink and black in various proportions varying from 10 per cent. black to 36 per cent. black, with an occasional individual producing only pink progeny, showing that in so far as color character of culture is concerned we have homogenic individuals of both the dominants and the recessives. Combining the pure dark with the pure pink by mixing either spores or mycelium gives rise to a uniform culture that is pink. Single-spore cultures from such a union give rise to cultures of four color types, pink, dark, yellow and purple, but apparently with no definite genetic ratios.

Inoculation experiments on onion seedlings with variants obtained from single spores also show considerable variation in pathogenicity, indicating that use of the single-spore method in obtaining pure cultures may prove confusing to both mycologist and phytopathologist.

The fact that *Phoma terrestris* breaks up into variants when singe-spore cultures are made indicates that segregation of character factors occurs, and the fact that it remains constant when it is perpetuated by mycelial transfers indicates that segregation takes place during pycnidium formation or spore maturation.

Tentative experiments with *Fusarium martii* var. *phaseolus* indicate that members of the genus *Fusarium* may behave similarly. The problem is being studied further by cytological methods.

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